NATIONAL DEFENSE INTELLIGENCE COLLEGE

SCIENCE + TECHNOLOGY = INTELLIGENCE ON TARGET

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Science + Technology = Intelligence on Target

Conference Proceedings
26 September 2006

NATIONAL DEFENSE INTELLIGENCE COLLEGE
WASHINGTON, DC
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The views expressed here are those of the participants and do not reflect the official policy or position of the Department of Defense or the U.S. Government.

The National Defense Intelligence College supports and encourages research on intelligence issues that distills lessons and improves Intelligence Community capabilities for policy-level and operational consumers .

These proceedings were the result of an initiative by the Joint Military Intelligence College (now the National Defense Intelligence College) to provide a springboard for new and expanded science and technology research and teaching at the College. To explore new directions and needs in Science and Technology research and to find better ways to involve the Intelligence Community, the College convened science and technology leaders from government and industry to share their ideas.

This publication is almost the entirety of their presentations, and the views expressed are those of the conference participants. The views do not necessarily reflect the official policy or position of the Department of Defense or the U.S. Government.

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Dr. James E. Lightfoot, Editor and Associate Director
Center for Strategic Intelligence Research

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INTRODUCTION

Introductory Remarks

A. Denis Clift
President, National Defense Intelligence College

WE WELCOME YOU TO THE *Science Plus Technology Equals Intelligence on Target* Conference. We are delighted you are here, and as you will see from our program, we are looking forward to a very good day.

In 1960, just a while ago, I was a naval officer stationed at the Fleet Intelligence Center Pacific when Francis Gary Powers' U2 was shot down. The news of his capture was a shock. The revelation of the U2 program was fascinating, and there was other news being whispered behind our closed doors, word of specially configured Air Force recovery planes flying out from Oahu on top secret missions. This was the dawning of intelligence from space, the recovery of the first film capsules from the Corona Program, science and technology on the march.

Mr. Clift welcomes the participants during his introductory remarks.

Years before, in his memoirs, *Their Finest Hours,* Winston Churchill described the painful shock he received in June 1940 when told that the Germans appeared to have developed a radio beam device that would guide their bombers over British targets, day or night, whatever the weather. A young scientist in the Air Ministry, Dr. R. V. "Reg" Jones, had made the discovery. He was summoned to the cabinet room to brief.

Jones described the evidence, the intelligence decoded from German enigma traffic that had led to the discovery of the beamed transmissions. He then went on to describe how the German system could be foiled, how beams could be bent, sending the bombers wide of their targets. Churchill would later call him to his bedside and tell him that when he had learned of the German beams, it had been his most tense, darkest hour, and then he had realized the most incredible relief when the young scientist had told him that the bomber beams could be foiled.

I would add that Reg Jones had a remarkable secretary, Daisy Mowat, who knew how to deal with the stresses of war. One day, Churchill's secretary called, and she told him Dr. Jones was not available. When Reg Jones did get to the phone, an aggrieved voice said, "This is Peck, the Prime Minister's secretary. Is that really you, Dr. Jones? I've just been talking to the most extraordinary lady, and she told me you had just jumped out the window." And Jones, with presence of mind, said, "Oh, don't worry. It's the only exercise we can get around here."

With Reg Jones as an inspiration, one of the College's strategic aims is to institutionalize the ethos and wherewithal for including science and technical aspects of intelligence in our research and learning. Just as today's conference underscores our dedication to the need for scientific awareness, in the near future we will be assembling other sessions, sessions at the classified level, where we'll be addressing in greater detail some of the breakthroughs and some of the challenges we are experiencing.

We will ensure that our curriculum embraces essential technical elements critical to every intelligence professional, and we will recognize and reward technical and scientific research by our students, our fellows, and our faculty. And I'm very pleased to say that the college will soon open a Center for Science and Technology in Intelligence, and through it we will seek out collaboration with men and women in the field around the world. In this early 21st Century, we are matching wits with those who would deny and deceive. We are on the trail and are defending ourselves against new and deadly forms of asymmetric weaponry.

Introduction

Dr. Anthony G. Oettinger, Chairman of the College's Board of Visitors,
Gordon McCay Professor of Applied Mathematics,
and Professor of Information Resources Policy at Harvard University

I AM PLEASED TO HAVE this opportunity to outline for you two important themes. One theme is that comparative advantage over our adversaries stems less from better science and more from better application of science through what I call "ideal technology." The other theme is that it takes close collaboration among diverse entities to realize this comparative advantage. I expect that subsequent speakers will develop these themes from their particular viewpoint.

In passing, let me say that I speak for myself only, not for Harvard University, nor for any of the other institutions that I have a relationship with, and I return to explain my two principal themes. In order to do that, I must remind you of how the spheres of science and technology, as well as the spheres of information and knowledge, relate to the spheres of intelligence.

The confluence of science, technology, and intelligence stems from two distinct but complementary imperatives. One is the imperative to use science and technology for running the business of intelligence, namely for collecting and storing information and for transforming information into the knowledge of commanders and policy-makers. The other imperative is that among its targets, the business of intelligence must include detecting threats to us that result from the use of science and technology by our adversaries.

I trust that we will leave this conference with practical, useful ideas about how to improve our nation's performance in responding to both of these imperatives. To think up those truly practical, useful ideas and to implement them most productively takes, I believe, close and steadfast collaboration among scientists, engineers, collectors, analysts, and operators, both from the public and the private sectors, and that cooperation must happen at all stages and at all levels of planning and of implementation.

Therefore, as a small step toward that goal, I would urge of you all to seek out at lunch people who work in different professions or disciplines and perhaps even in different organizations and not simply stick with your normal buddies.

The worth of intelligence, both to our nation and to our adversaries, stems from essentially the same factors as the worth of science. Why? Because both science and intelligence are forms of knowledge and so are such arts as

diplomacy, military strategy, and medicine. Many factors determine the worth of any kind of knowledge. These factors include the extent of that knowledge, the specialization of that knowledge, the validity of that knowledge, and the practical and effective applications of that knowledge. The better, the more extensive, the timelier, and the more judiciously and effectively applied our own knowledge is relative to the knowledge applied by our adversaries, the greater is our own knowledge, and the greater is our comparative knowledge advantage.

All of that, all of the foregoing, is timeless truth that is attested to by experience from China's Sun Tzu to the contemporary globalized scene. Now, what is new in the present globalized scene, and what will persist for the foreseeable future, is that the judicious, effective application of knowledge is the one factor that in my mind dominates all the other factors in determining the worth of knowledge and the degree of comparative knowledge advantage.

What's my point? My point is that the quality, the extent, and the timeliness of available knowledge have become universal. It follows that these factors no longer confer comparative advantage. Why is this so? Because information, like money, can nowadays spread all over the world at Internet speed, and it is so because knowledge likewise spreads all over the globe, just more slowly and unevenly than information.

Why more slowly and unevenly? Because it takes people, and it takes organizations to produce knowledge by assimilating and by transforming information, and because knowledge tends to fade in the heads of people, and because knowledge tends to get buried in the files of organizations.

So knowledge, therefore, travels at most at the speed of people in jet liners, and usually even more slowly than that, because people acquire knowledge, and people share knowledge at less than jet speeds, and because organizations suffer from bureaucratic barriers and delays. Still, much, much sooner nowadays, instead of much, much later in the good old days, knowledge spreads out from its birth place and goes global.

Specifically gone is the near duopoly of science that the United States and the Soviet Union enjoyed over the rest of the world in the period from the rise of Hitler in the 1930s to the opening up of space in the 1960s. Thus, the scientific knowledge available nowadays in Pyongyang and Tehran and even in Tora Bora is as good, as extensive, and as timely as it is in Silicon Valley, Tokyo, Beijing, and Mumbai.

Going, if not gone, is the near monopoly that certain governments enjoyed in realms such as nuclear and space affairs, and when governments no longer have a monopoly, the national intelligence enterprise must perforce rely on collaborating with the private sector more closely and more extensively than ever before. In the environment of all-pervasive knowledge, these close collabo-

rations must necessarily encompass diverse disciplines, professions, agencies, companies, sectors, and even countries.

The judicious and effective application of knowledge through such close collaboration is nowadays the only way to create a comparative knowledge advantage. That judicious and effective application of knowledge, knowledge that includes art, diplomatic, military, medical, whatever, as well as science, is what technology is all about.

Most people believe, perhaps with the exception of the people in this room, that technology is merely about tools, instruments, gadgets, listening devices, cameras in space, iPods, and so forth. But technology is not merely about tools. The best of tools are worthless in incompetent hands, in dysfunctional organizations, or when deployed under ill-suited rules of engagement, ill-suited doctrines, or ill-suited legal or management regimes, in short, under ill-suited policies.

Applying knowledge judiciously and effectively implies having appropriate tools held by competent hands in appropriate organizations under appropriate policies. That whole collection of components is what I call ideal technology. History tells us that the importance of these softer human components of ideal technology, the competent hands, the appropriate organizations, the appropriate policies, can readily outweigh the importance of the tool components of ideal technology.

Two examples come to mind. President Clift just reminded us of Winston Churchill and Reginald Jones and the use of technology to counter the adversary forces and their technology. The use of technology as a multiplier of one's own forces will serve here as my first example of the importance of the human components of knowledge.

It's well known that the British won the Battle of Britain in World War II because the Royal Air Force used the tool of radar, then brand new, for intelligence with which to assist relatively few fighter pilots, competent people, who flew a relatively few spitfires, an outstanding new tool, to down relatively many German bombers. Less well known is that it was tactical invention and organizational innovation, namely those softer human components of ideal technology, that played the crucial role in the success of pilots, spitfires, and radar by creating what modern parlance terms a force multiplier.

The British and the Germans both had developed roughly equivalent radar and aircraft tools. The leaders of British fighter command daringly abandoned their established tactic of spreading their fighter force evenly and woefully thinly all over the British coastline, and instead they concentrated their entire small fighter force where radar told them that German bombers were actually coming in.

This tactical innovation not only helped the RAF to down many more German bombers than it could have under the old approach, it also confused German strategy by implying to the Germans, who used the old mind set to interpret what they saw, that the British had a huge fighter force held in ready reserve along the rest of the perimeter, a force that did not actually exist.

The second example is all too well known by all of us here. Al-Qaeda created a brilliant tactical innovation based on applying open and widespread knowledge. In the 9/11 attacks on the World Trade Center and the Pentagon, it successfully turned against us the fruits of our own science and technology. By imaginatively and skillfully combining existing tools in novel ways, Al-Qaeda used the Internet and other commercial communications facilities for command and control, and it used commercial jet liners as weapons, as commonplace tools used in new ways to create novel capabilities.

These examples and many others have also taught me the importance of collaboration. This is because deploying what I call ideal technology, namely fielding competent hands who apply knowledge judiciously in appropriate organizations under appropriate policies using appropriate tools, demands close and steadfast collaboration among people from diverse disciplines, professions, agencies, companies, sectors, and, as I said before, even countries.

In the 20th Century, we made great strides in developing the tool components of ideal technology, and tool making remains a serious challenge in the 21st Century, but the greatest challenge remains to improve and to refine those softer human components of ideal technology. Just consider some of the pathologies that can result from the absence of close collaboration.

Think of how many systems you have seen that were developed by engineers who only reasoned abstractly about how to help someone do a job or to transform that job and who never got close to real people doing the real job under real conditions. Think how many well-intentioned operators you know who unwittingly ordered up tools ill suited to their operational goals or tools that were nothing but vaporware touted by unscrupulous vendors.

Consider further that if, indeed, it is the judicious application of knowledge that is the key to comparative knowledge advantage, then knowing adversarial intentions rose in importance relative to knowing adversarial capabilities as a goal of national intelligence. It follows that human intelligence, human source intelligence, HUMINT, also grows in importance relative to all the other INTs, as do new tools that support HUMINT missions. These new tools in the hands of human collectors, ours and the adversary's, may enable those collectors to perform collection missions unimagined before.

Note that knowledge of capabilities remains important in absolute terms. As illustrated by the events of 9/11, novel capabilities can stem from

applying novel combinations of existing tools, but here also, HUMINT grows in relative importance for spotting and countering the conception of those novel combinations of existing tools.

So, as you listen to today's speakers, I urge you to evaluate the merits of the diagnosis that they offer and of the treatments that they propose according to criteria. First, how close are these treatments to ideal technology, whereby competent people apply knowledge in appropriate organizations under appropriate policies using appropriate tools? And second, how close and steadfast is

Dr. Anthony Oettinger shares asides with other conference participants.

the collaboration among operators, analysts, techies, and many other types, in and out of government, in developing and implementing these treatments? I thank you for your attention.

Dr. Rita Colwell presenting the Keynote Address.

KEYNOTE SPEAKERS

Climate and Infectious Disease: The Cholera Paradigm

Keynote speaker, Dr. Rita Colwell
Professor, University of Maryland College Park and Johns Hopkins University Bloomberg School of Health
Chairman, Canon U.S. Life Sciences, Inc.

I'M GOING TO SPEAK ON science and security in a connected world. I'm going to do it in a way that's probably fairly unusual in that you've read in the *Washington Post* front page yesterday that we're still chasing the anthrax perpetrators. I'm going to give you a background of why it is so difficult in the modern era of technology and science to be able to pull out from a given source the microorganism that was involved let's say in the anthrax case but could be any one of four or five other serious agents.

We need to expand our collective vision. The journalist Tom Friedman has written, "The World Trade Center is not the place where our intelligence agencies failed. It's the place where our imaginations failed." So I'm going to speak today about tracking microorganisms in the environment, but key is that partnerships among us, the intelligence agencies, the military, science, academia, are essential to ensure our security in the 21st Century.

And the challenges are technical, they're complex, and they're global. They might be termed inevitable surprises. Peter Schwartz calls them that in his book with that title. "There'll be many more moments to come," he writes, "when the assumptions that you've lived by suddenly fall away."

So it's scientific truth and intelligence that have parallels that help us anticipate the surprises and the pursuit of meaning within a deluge of data where answers require mastering multi-disciplines, multi-cultures, and multi-dimensions. And today the mythical image of a butterfly beating its wings in Brazil, which sets off a disturbance that eventually becomes a tornado in Texas captures a very deep truth about our world.

And the tsunami in the Indian Ocean a few years ago literally made waves around the planet. And in human societies under the new regime of globalization, which is a real life sorcerer's apprentice, a single person or a group can set off echoes across hemispheres for good or evil. Globalization binds our shrinking world through trade, travel, and communications, so in this round world that's gone flat through connectivity, we have a Japanese super computer that crunches global weather patterns so fast that it takes the lead as the world's fastest super computer, at least for a little while.

In the field of nanotechnology, Chinese researchers publish more articles than their U.S. counterparts. India has transformed itself from a

famine-ravaged land. I can remember years ago when we used to worry about the famines in India, and now it's the incubator for the most advanced computer engineers in the world.

So as a microbiologist, I want to underscore that today's world faces a really vexing challenge, and it's imperative to understand this new kind of adversary, who has a new kind of weapon. And we need to overcome the cultural barriers that keep the biological scientists and the defense community apart, and I think a lot of work is being done in that arena, but we need strong partnerships between the biological community and the defense and the intelligence communities.

Now neither a U2 plane nor a satellite can spot someone stirring up a pot of smallpox in a garage or a cave. Today an individual almost anywhere in the world with a high school knowledge of biology can grow bacteria, and I was appalled to read that now they are marketing do-your-own biotechnology in your garage. For as little as $50,000 you can set up your laboratory. That really worries me.

Anybody with a high school knowledge of biology can grow bacteria and weaponize them, and we no longer have to imagine what the cost will be, besides the loss of five lives of anthrax contamination in the postal system right here in Washington. That was about a billion dollars. And we don't have to imagine a scenario of how our milk supply could be contaminated by botulinum toxin.

A recent study showed this and also that the potential threat can be eliminated if we just test properly at the cost of less than one cent per gallon. And we've been watching for the last couple of weeks the E. coli 0157:H7, a really nasty bacterium that essentially perforates the intestine and causes bleeding and death.

So to anticipate the threats, we need to discount our outmoded conventions. The students in medical school used to be taught that if you hear the clattering of hooves, don't look for zebras, meaning don't look for the exotics. But today in the global world, we have to be open to the whole menagerie of everything.

Now let me give you some information, and you may wonder why I'm doing so, but I think—I hope at the end of the discussion—that you will understand that what we must do in this 21st Century is understand infectious disease, drawing from a context, a series of contexts, each of them nesting like a concentric circle within the next. We have to employ nanoscience, genomics, ecology, geography, social science, climatology, and mathematics to understand infectious disease in the 21st Century.

The connections between cholera, an ancient water borne disease, which I will use as my example this morning, and the environment, provide a

paradigm, because we need a multidimensional understanding of an infectious disease, and we need an international perspective as well.

Now here I'm going to speak very briefly about what I view as the concentric circles that surround infectious diseases. I'll talk a little bit about the international setting, the philosophical construct of what I call biocomplexity, multidimensional and multidisciplinary approaches, and infectious diseases and their ecological context, which makes it so difficult to determine when you're dealing with bioterrorism.

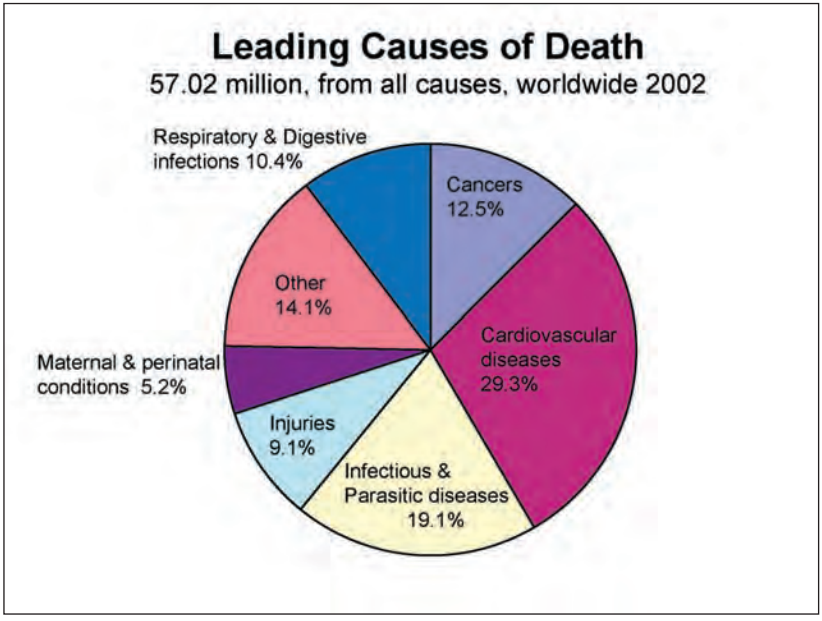

Figure 1. Leading Causes of Death, Worldwide. *Source: World Health Report, 2005.*

This is a quick snapshot from the World Health Organization that puts my discussion into perspective. Infectious diseases cause about a quarter of the deaths worldwide. These don't include cancer, cardiovascular and respiratory diseases, some of which are now being shown to be caused by infectious agents.

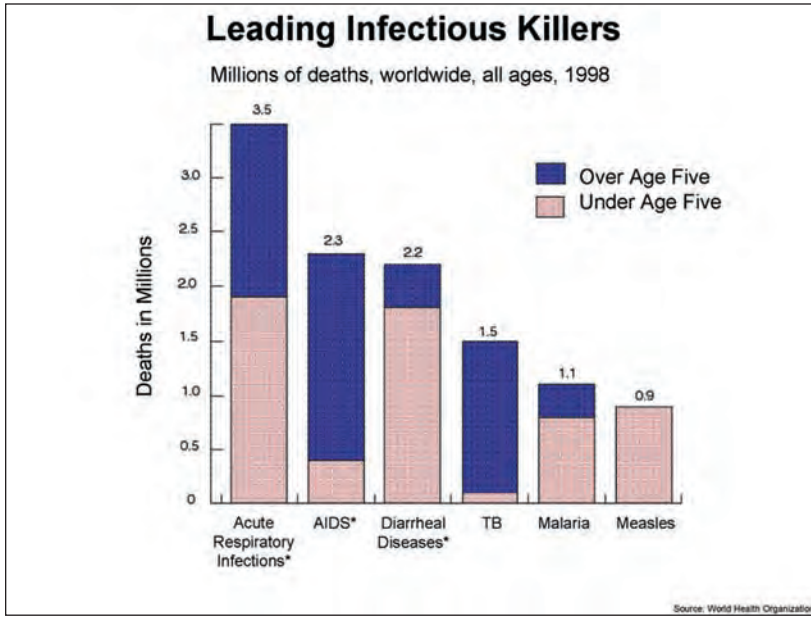

Figure 2. Leading Infectious Killers. *Source: World Health Organization.*

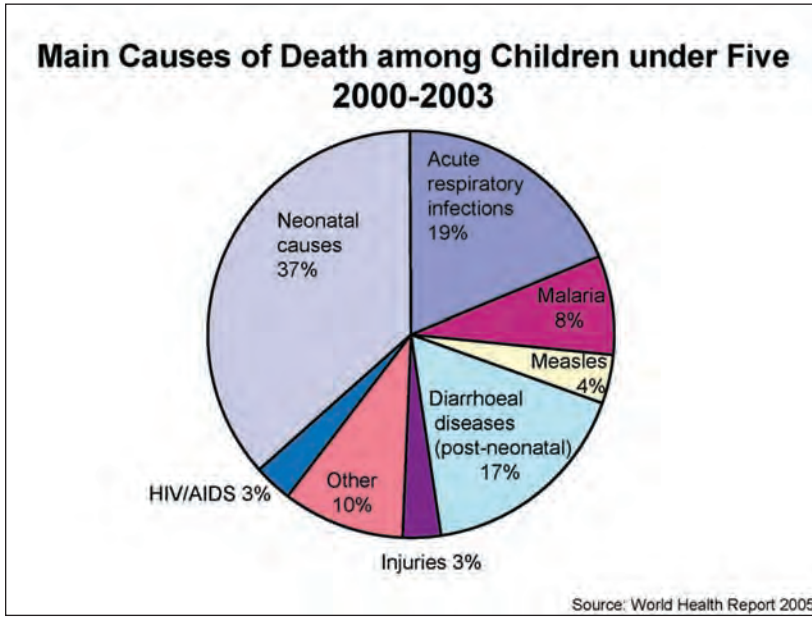

Figure 3. Main Causes of Death among Children under Five. *Source: World Health Report, 2005.*

The major killers are broken down into six, the acute respiratory infections, AIDS, and diarrheal diseases. Diarrheal diseases used to be number one. They still are for children under the age of five. And so we have to consider when we zero in on the diseases, we have to understand the larger concentric circles that frame today's global context for the environment and health.

Cholera remains a major killer among the diseases, and you can see that in the number of outbreaks in the period of `98 to `99, and it continues for 2004-2005, as the major killer, particularly of young children. What's the context? It's travelers. Goods and diseases circumnavigate the globe ever faster.

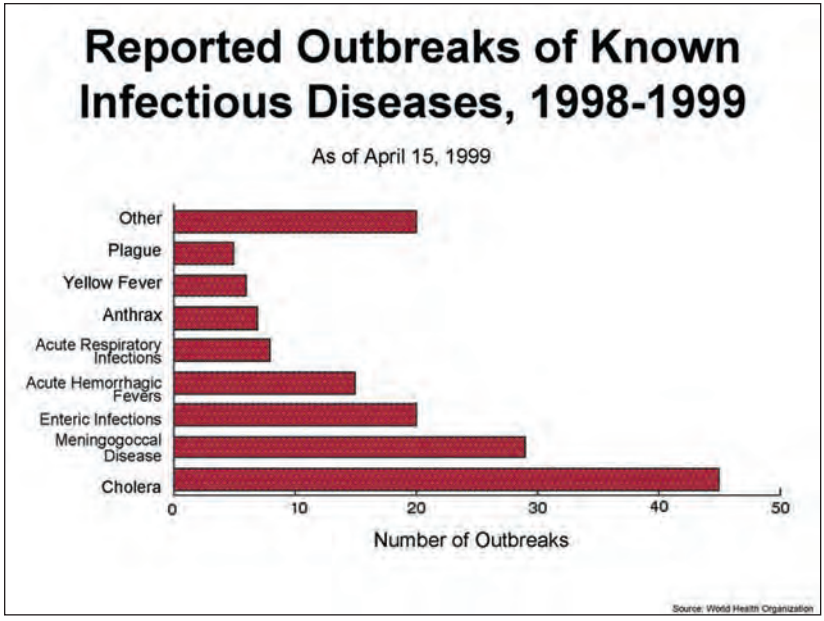

Figure 4. Reported Outbreaks of Known Infectious Killers, 1998-1999. *Source: World Health Organization.*

And here we see where all these travelers are arriving from. This was up—the slide goes to 1990, but I can assure you that we now as of 2005 have 700 million international arrivals, and the Middle East, Africa, South Asia, the Americas, East Asia represent the major places where these travelers are arriving.

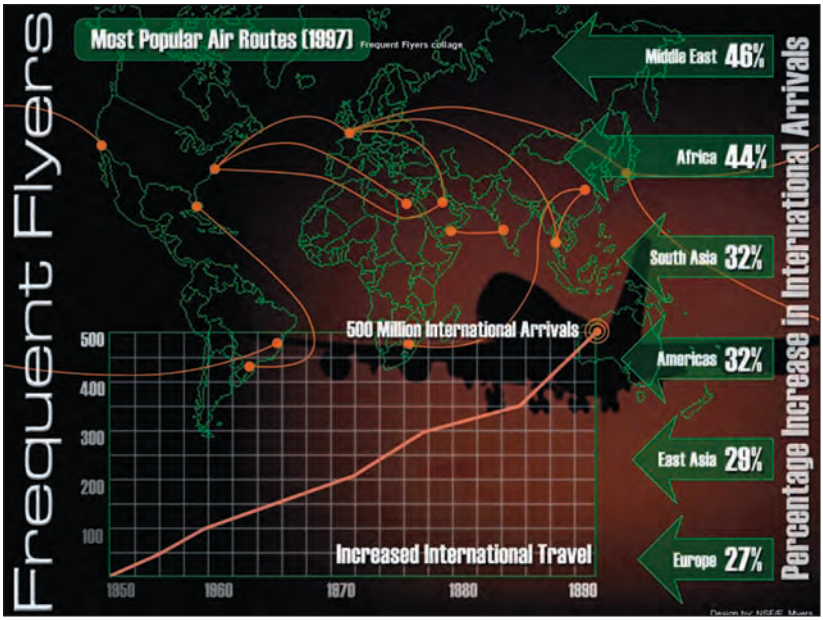

Figure 5. Most Popular Air Routes (1997). *Designer: NSF/ E. Myers*.

Now while travelers and goods are circumnavigating the globe ever faster, so does knowledge. In the case of SARS (Severe Acute Respiratory Syndrome), for example, there was an initial delay in the news that the disease was spreading, but the world's response was swift. Canadian and U.S. researchers were able to map the virus genome in a matter of weeks.

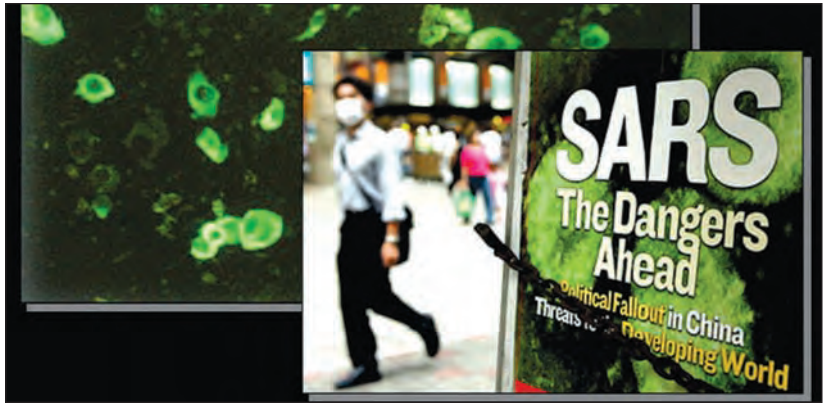

Figure 6. SARS, The Danger Ahead. Source: *AFP/Peter Parks/Yahoo News*.

And today, SARS researchers can go on the Web, and they can download sequences of the Corona virus, the type of virus causing SARS, that have been posted by researchers all over the world. This is an unprecedented intensity in rapidity of international cooperation. It's reassuring in that rapid progress was achieved. It shows that scientific endeavor is as global in scale as the problems and the pathogens we target.

The international arena that I've described is one context. Another is conceptual, and this is the framework I call bio-complexity, which denotes the study of complex interactions in biological systems, including humans and their physical environments. Ecosystems don't respond linearly to environmental change, and neither do the pathogens that live in them.

Figure 7. Biocomplexity. *Source: NSF/S. Raimo.*

And so the spiral, I think, is very symbolic of life at every level to underscore the point that understanding demands observing at multiple scales, from the nano to the global, and the spiral of complexity unfurls at the most minute scale of the atom, curves up through successive levels of life through the cell, the organism, the community, the ecosystem, and complexity principles emerge at each level. And so the disciplinary worlds fade away. The silos of disciplines need to be horizontally connected.

Training the phenomenon of biocomplexity on helping the environment, we learn how linear and simplistic is the notion that we can eradicate a disease from the face of the planet. Infectious diseases are a moving target. As the climate shifts, any disease with an environmental stage or vector is going to be affected, and so we need to recognize the signals from climate models.

We need to incorporate them into health measures, and that will give us new opportunities for proactive, rather than the reactive responses to public health. In fact, it allows us to have a preemptive medicine, which I think will be very important in the 21st Century.

I'm going to give you a few cases, very quickly, of infectious diseases that are associated with the environment. Ecology has immediate lessons for epidemiology. The mosquito that lays eggs in these beautiful North American carnivorous plants, the pitcher plants, is one that is very similar to the malaria-carrying mosquito. It works as a good model for the point that I would like to make.

Figure 8. Pitcher Plants. *Source: William E. Bradshaw.*

The mosquito that you see is not the disease vector, but it acts similarly to the disease vector for malaria. The adaptation of this mosquito, which was formerly a tropical insect, to the climate grading of North America gives us insight for infectious disease.

The mosquito, like many organisms, uses day length to regulate seasonal development. Mosquito populations have adapted to the climate of North America from Florida to Canada. The disease-carrying invaders like the Asian tiger mosquito similarly adapt to cold and to different day lengths. As spring comes earlier, and the growing season has lengthened over the last half century, the pitcher plant mosquito has adapted to shorter photoperiods, especially in the North. So there is adaptation that occurs with these vectors.

In the rare example of a documented genetic shift due to warming, as the latitude increases, the mosquito's genetic chromosomes shift to shorter photoperiods. That is, gene changes occur, and this is evolution at breakneck speed, and that is what we need to understand. In the case of

Hawaii, there's another vector-borne disease, avian malaria, and neither the mosquito nor malaria are native to the Hawaiian Islands, but the system involves introduced disease.

Figure 9. Pitcher Plant with Mosquito. *Source: William E. Bradshaw.*

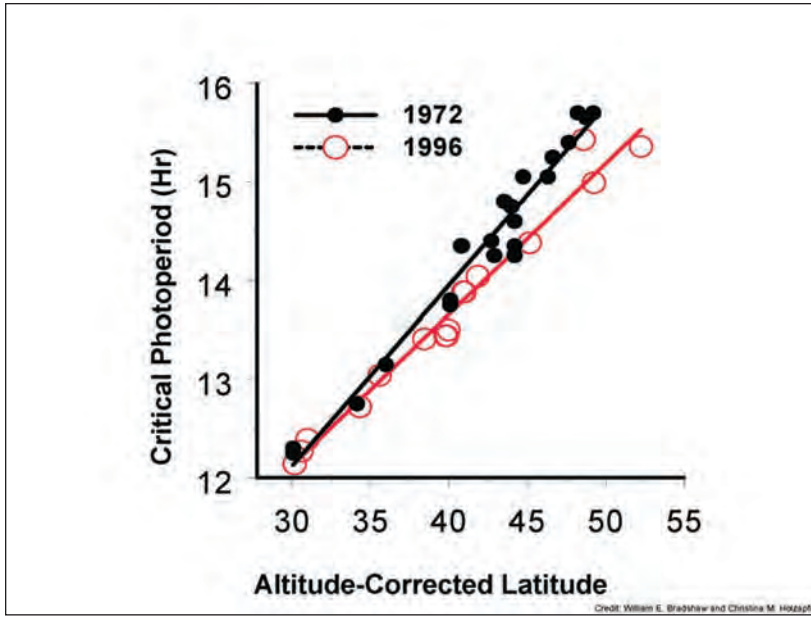

Figure 10. Critical Photoperiods by Latitude. *Source: William E. Bradshaw and Christina M. Holzapfel.*

Figure 11. Mosquito on Bird's Eye. Source: *David Cameron Duffy.*

It serves as a model for emergent mosquito-borne diseases like West Nile virus in North America, and I was appalled to learn, having just returned from Idaho giving a talk at the University there yesterday morning, that the West Nile disease has reached Idaho, causing a number of deaths in the last year. In fact, they had to resort to spraying this August in order to deal with that particular infection. It has moved very rapidly in a short time from New York, across the Midwest, and now it's settled into Idaho.

The Hawaiian situation is complex, because Hawaii has lost about three quarters of its bird species to extinction since humans arrived. The diseases, avian malaria caused by mosquitoes, avian pox carried by introduced mosquitoes, are the current threat to the Hawaiian rain forest birds.

Figure 12. Hawaiian Rainforest Birds. *Source: David Cameron Duffy.*

Another example is a story of a pathogen intertwined with climate. This one began in 1993 in the four corners area of the United States. Young, otherwise healthy people began dying from an unknown disease. We suspected bioterrorism. The culprit turned out to be hantavirus. It was unknown in the new world until that outbreak. Now most of us have heard about it. The mortality rate of those infected with that virus was 70 percent in the first few weeks. The question was, "Was this a mutant?" Had the environment been harboring it all the time?

Figure 13. Deer Mice. *Source: Linda Broome.*

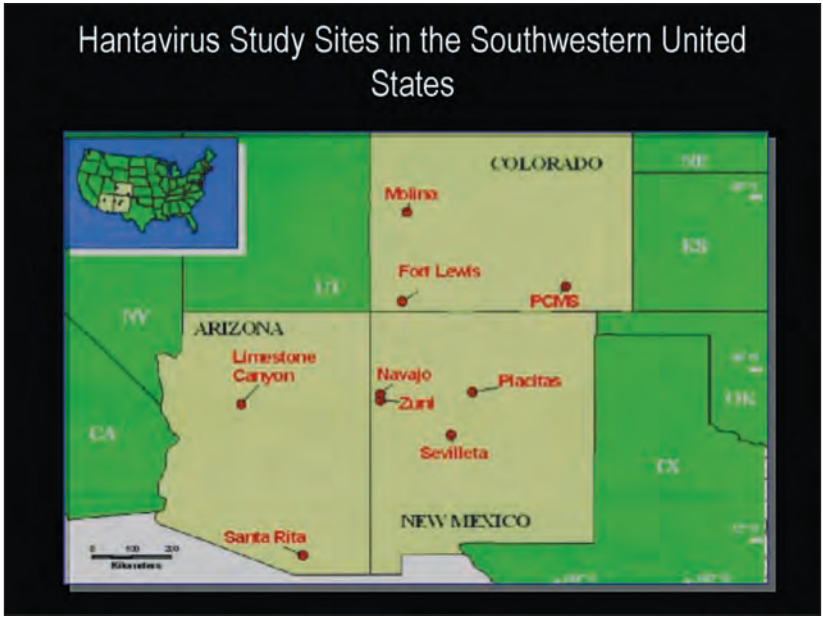

Figure 14. Hantavirus Study Sites in the Southwestern United States.
Source: Author.

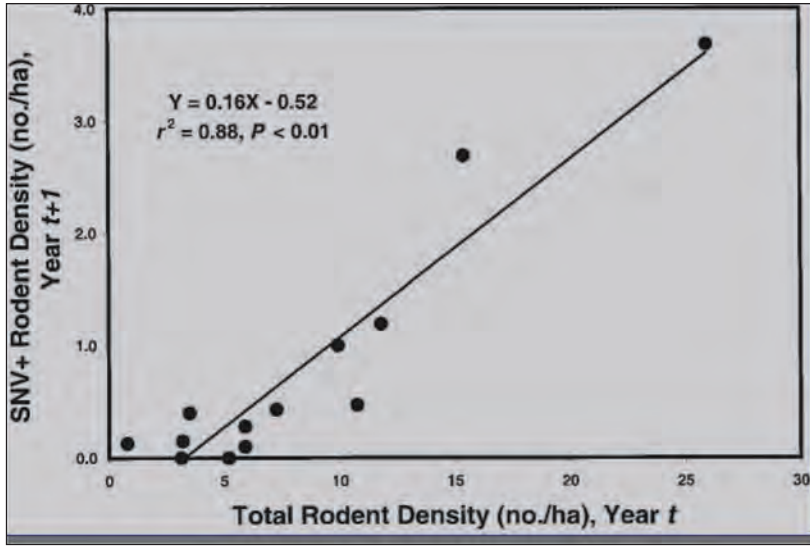

Figure 15. Correlation of Sin Nombre Virus to Rodent Density. *Source: Terry Yates, University of New Mexico.*

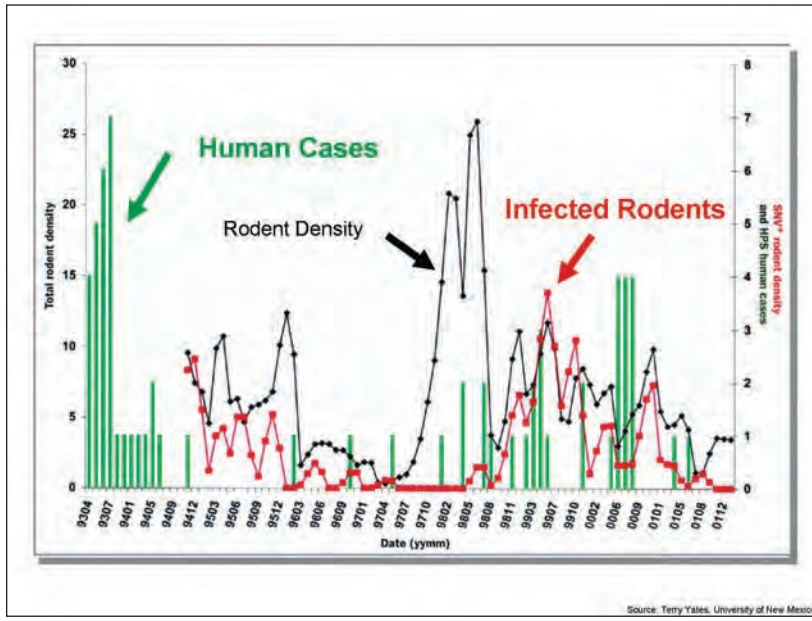

Figure 16. Human Cases of Hantavirus Related to Rodent Density and the Number of Infected Rodents. *Source: Terry Yates, University of New Mexico.*

Figure 17. Hantavirus Discovery Locations. *Source: Terry Yates, University of New Mexico.*

The carrier turned out to be a rodent, the deer mouse. These are the study sites in the four corners area of the United States. Because the National Science Foundation had been funding a 25-year program, long-term ecological research sites, this being one of them, they had mouse tissue archived, and so the investigators, Terry Yates from the University of New Mexico, and Gregory Glass from Johns Hopkins University, were able to track the virus in these archived tissues.

The investigators showed a link between climate and the outbreak of the disease. The mild and wet winters associated with El Niño provided more food for the mice. The populations increased dramatically in 1993, and eventually the researchers found a time lag between the mouse population increase and the human infections.

And it turns out that it is the infected mice—when you have very large populations, the virus is transmitted rapidly, infecting lots of mice, and then the infected mice move in when the food declines because of the non-El Niño years. They move into the barns, and in their urine they excrete the virus. It dries. Humans come in, sweep up the barns, inhale the dust, and then contract the hantavirus.

Now what's interesting is that this map shows the hantaviruses, and all but one have been discovered since 1993, so these viruses were in the environment all the time and have been isolated since 1993 from a variety of locations.

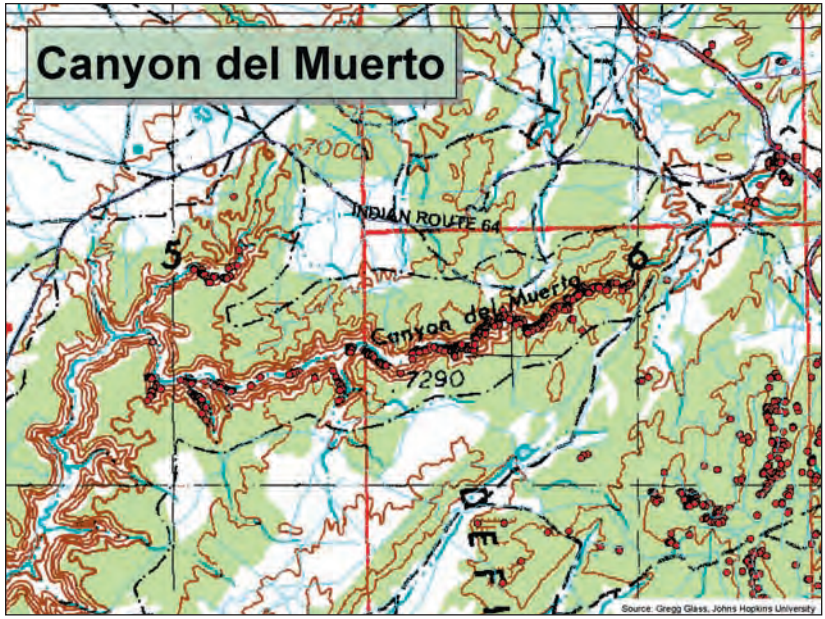

Figure 18. Cañon del Muerto. *Source: Gregg Glass, Johns Hopkins University.*

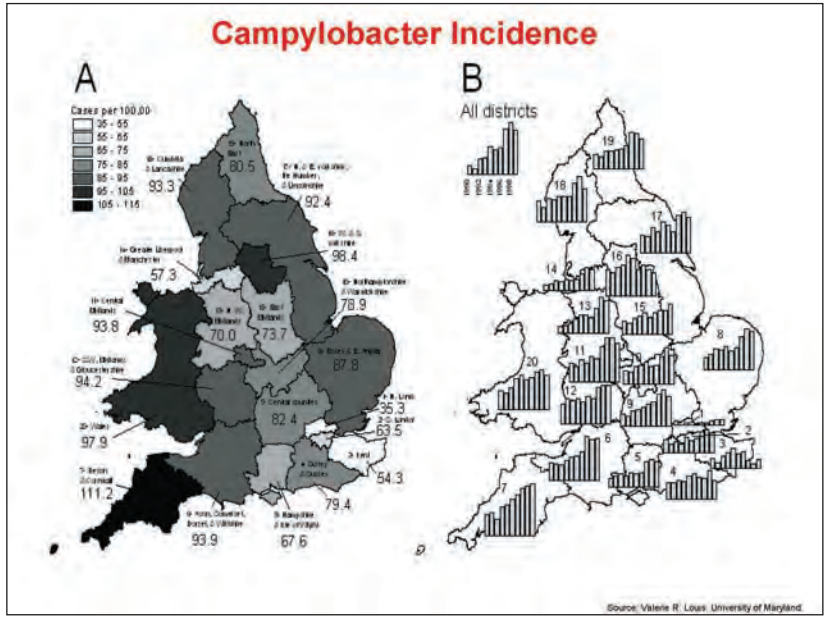

Figure 19. Campylobacter Incidence. *Source: Valerie R. Louis, University of Maryland.*

And, in fact, our Native American Indians knew about the hantavirus in sort of a way, because when Terry Yates and Greg Glass developed a computer model to predict where most like the hantavirus would be found, all those little dots are in the Cañon del Muerto, the Canyon of Death, which the Native American Indians had understood that if you went into that canyon, you wouldn't come out alive. Now we know it's hantavirus.

Another infection is campylobacter. This a very serious diarrheal disease caused by a bacterium. It was a leading disease as of a quarter of a century ago, particularly in England, Scotland, and Wales. It is another potential bioterrorist agent. It causes bleeding of the gastrointestinal tract and can cause death, especially in children.

Now in England they spent a lot of time working on food-borne transmission that had been traced to chickens, but notice in the right-hand graph, all the incidence curves are going up. It turns out that, in fact, the organism is water-borne and that it has a very distinct seasonality. Each year, without fail, you can see in January, February, March from 1990 through 2000, the data show that it peaks in the spring.

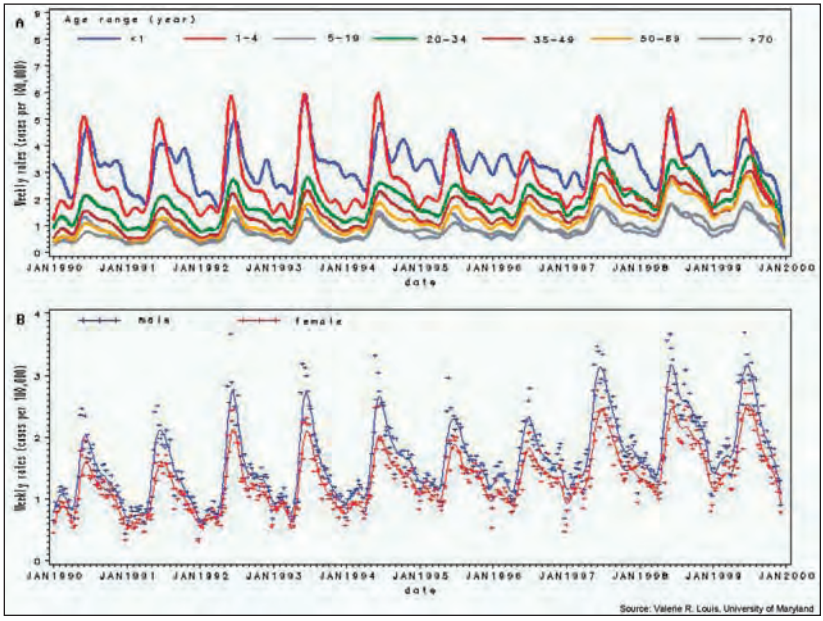

Figure 20. Campylobacter Seasonality. *Source: Valerie R. Louis, University of Maryland.*

It is due to surface water being contaminated by both the cattle who are let out of the barns in the spring and the numbers of lambs that are born. So this, then, requires that we understand the background of this disease, which is, again, as I say, a potential bioterrorist agent.

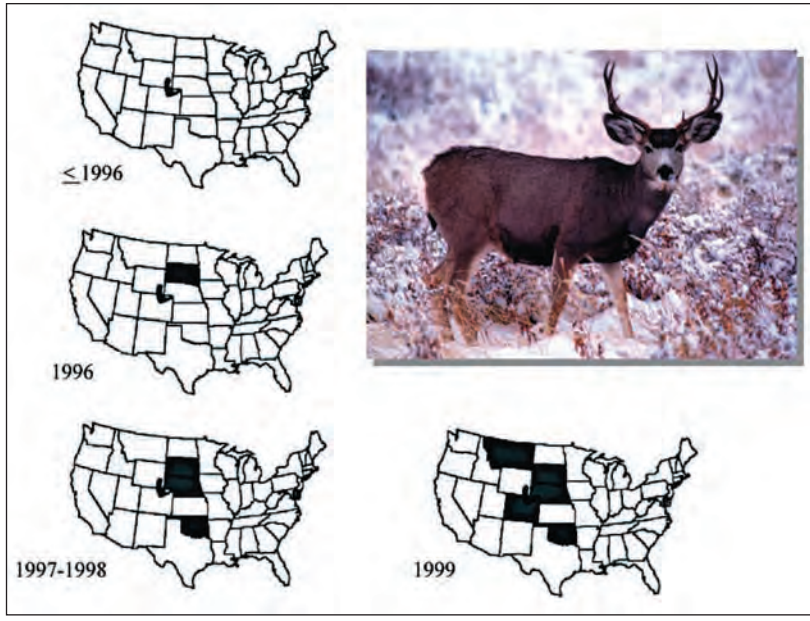

Figure 21. Spread of Chronic Wasting Disease in Mule Deer. *Source: N. Thompson Hobbs, Colorado State University.*

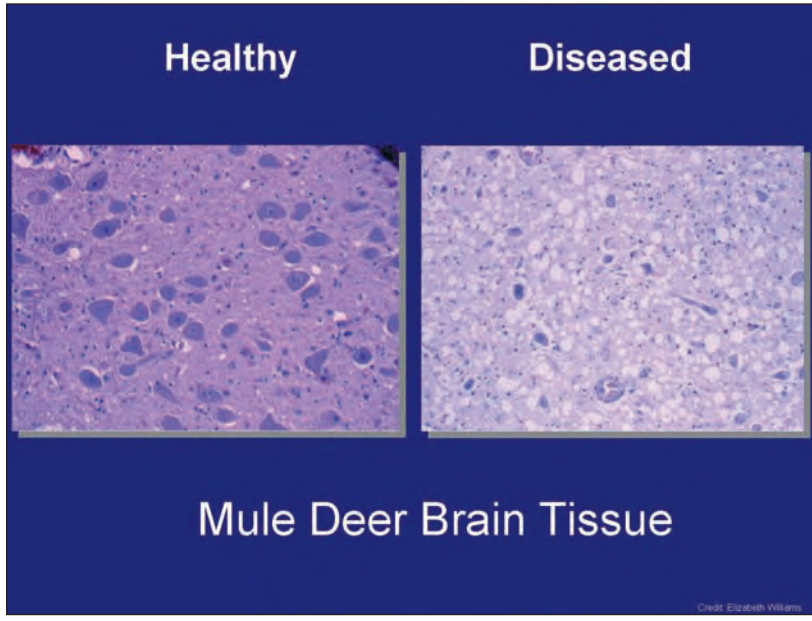

Figure 22. Mule Deer Brain Tissue. *Source: Elizabeth Williams.*

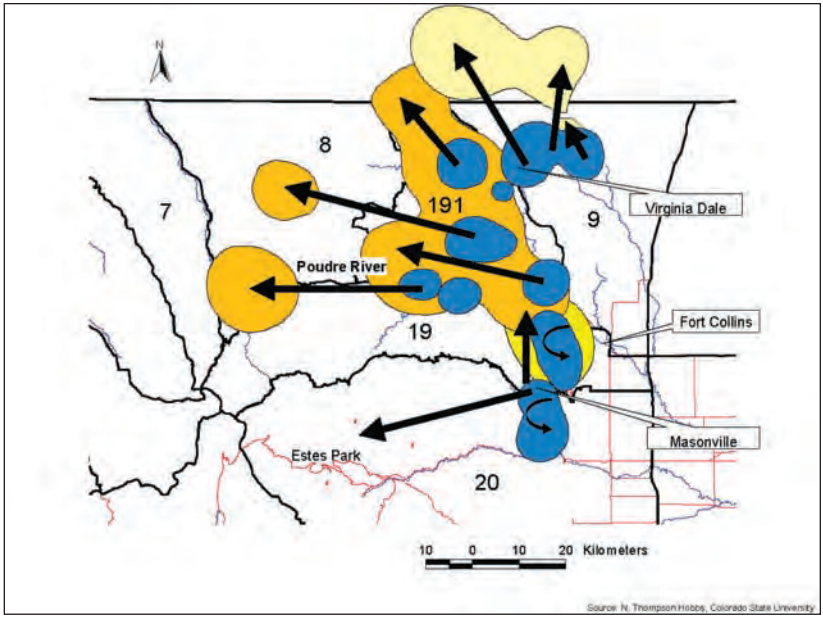

Figure 23. Summer and Winter Movements of Mule Deer in Colorado. *Source: N. Thompson Hobbs, Colorado State University.*

Figure 24. Snow Map of Cholera Cases, 1854. *Source: Author.*

Here's another example, which I think is rather fascinating. It's a complex disease in a wild animal population, but it has implications for human health. It's called chronic wasting disease in mule deer. The data are from `96 to `99, but I have been told by my colleague Tom Hobbes at the University of Northern Colorado that now it includes almost all states in the West except for perhaps California.

This is caused by a prion. Prion is a protein with no nucleic acid. We know about it because it was the cause of mad cow disease or the Creutzfeldt-Jakob disease in humans. And the images show the brain of a deer who is healthy and the diseased deer, very similar to the effect in humans.

Now here we see the plot of the summer and winter movements of mule deer in different game management units. The disease dynamics unfold in an environment that's undergoing dramatic change. This disease

Figure 25. The Broad Street Pump. *Source: Author.*

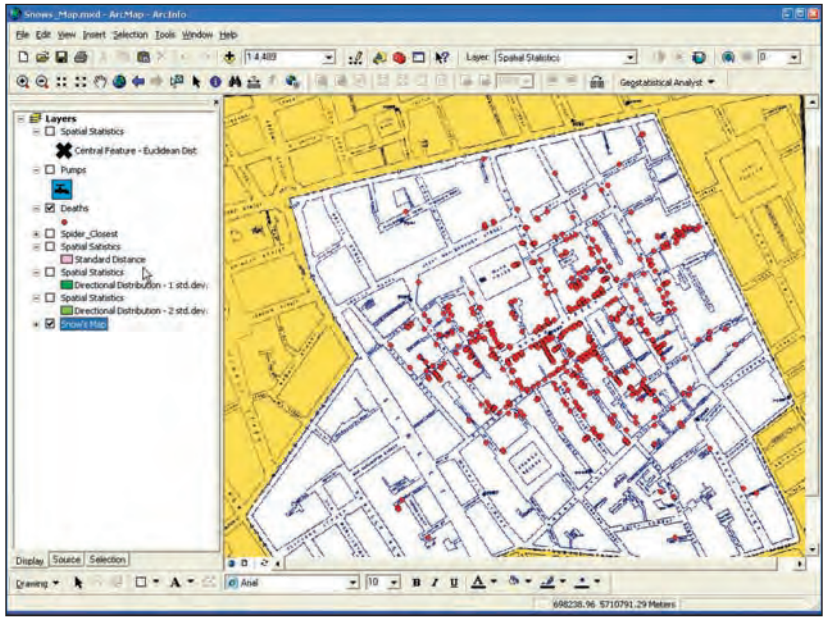

Figure 26. Snow Map with Cholera Death Locations. *Source: Author.*

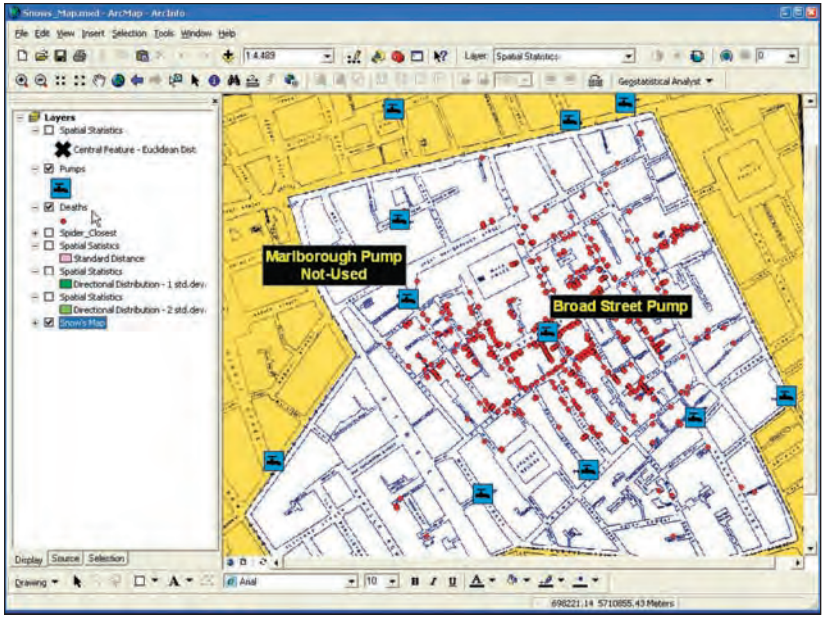

Figure 27. Snow Map with Deaths and Water Pump Locations. *Source: Author.*

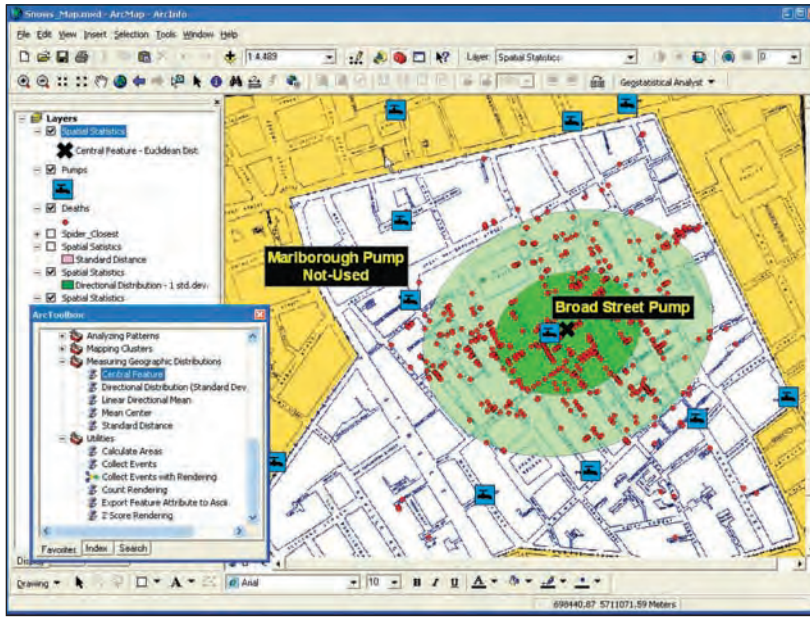

Figure 28. Snow Map with Deaths, Water Pump Locations, and Geographic Distribution Analysis. *Source: Author.*

now has moved into much of the western part of the United States in one of the fastest growing human populations in the country. It is a good example of how one could introduce hoof and mouth disease very easily into populations, and a spread would be enormously rapid, which would end up with economic disaster for our country, essentially the elimination, at least for a time, of our cattle industry.

So these are the concentric circles, from malaria to hantavirus, prion diseases, and let me talk about cholera, because here we do have some very interesting tools that allow us to do some prediction and hopefully prevention. Rigorous study of the spread of cholera goes back to 1849, when it was argued as to whether germs caused disease, and John Snow did a very interesting thing. He simply mapped, and this is taken from his publication in 1854, the cases of cholera, and he found that they all were around one particular well in downtown London, the Broad Street pump.

Well, the myth is that he took the handle off the pump, and cholera dissipated, but actually what he did was plot the data, and in September, when it would have abated anyway for reasons I'll explain in a moment, the disease did go away, but I think it's important to understand that he was accurate. We took his data, ran it through GPS, GIS, did some calculations, and he's right—John Snow was quite precise.

Cholera Cases Officially Reported to WHO 2004

Selected Countries

Country	Number of Cases	Imported	Deaths	Mortality Rate
Benin	642		9	1.40%
Burundi	819		14	1.71%
Cameroon	8005		137	1.71%
Comoros	1		0	0.00%
Cote d'Ivoire	105		9	8.57%
DROC (Congo)	7,665		228	2.97%
Niger	2178		57	2.62%
Nigeria	3,186		185	5.81%
Somalia	4,490		26	0.58%
Uganda	3,380		91	2.69%
Tanzania	10,319		272	2.64%
Zambia	12149		373	3.07%
Zimbabwe	119		9	7.56%
India	4,695		7	0.15%
Japan	66	55	0	0.00%
Singapore	11	1	1	9.09%
Total	57,830	56	1,418	2.45%

Figure 29. WHO Reported Cholera Cases: 2004. *Source: World Health Organization.*

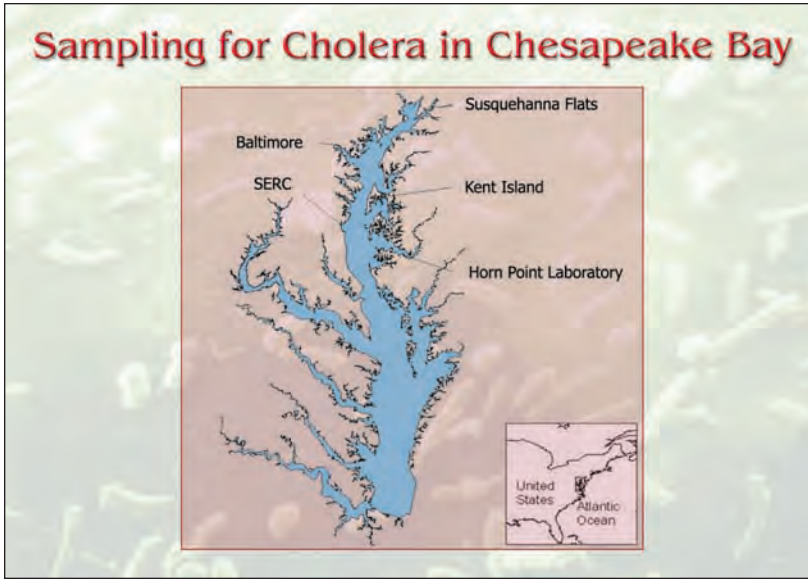

Figure 30. Sampling for Cholera in Chesapeake Bay. *Source: Author.*

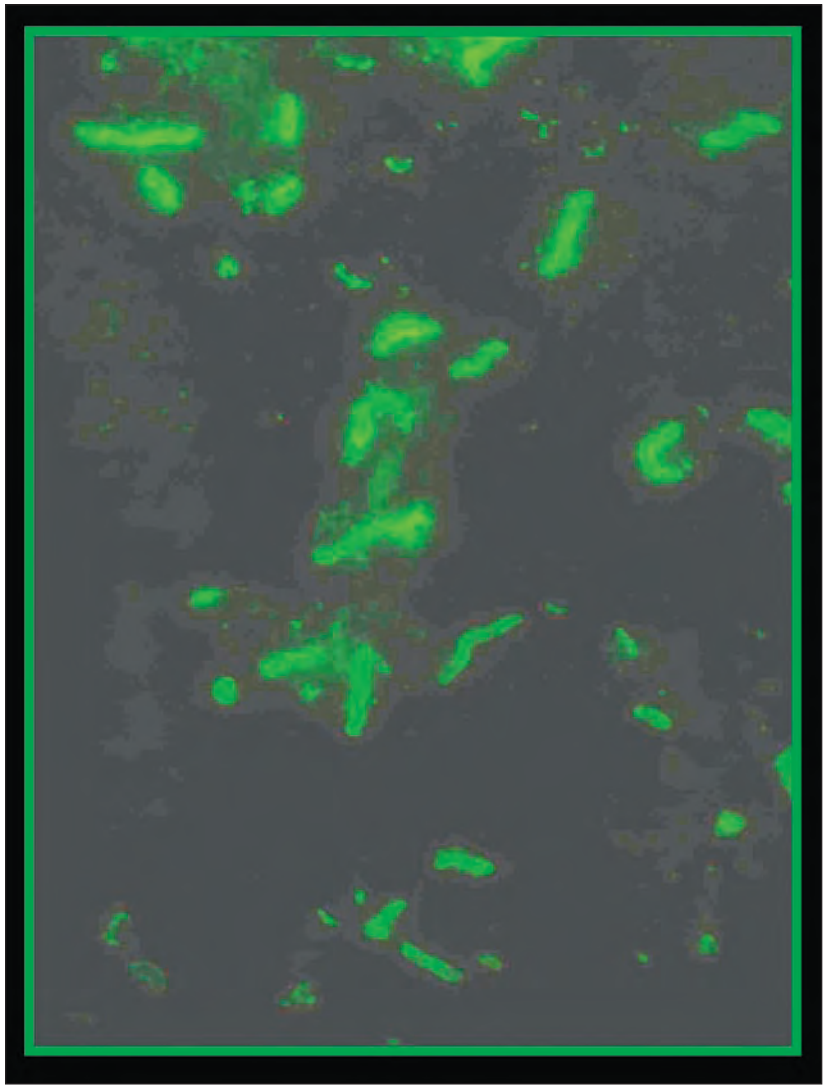

Figure 31. Cholera Bacterium. *Source: Author.*

Now cholera is a devastating disease. It's a Class B bioterrorist agent. These show data, the most recent data I could pull down from the web for 2004. It does not include Bangladesh. If you add the Bangladesh data, it's 100,000 cases. The number of deaths is probably closer to 4,000 or 5,000, in a very bad monsoon years, 10,000, so it's a disease that's very much with us.

It's a disease that goes with chaos and social disruption like we have seen in Rwanda, Somalia, Ethiopia. I was on the plane coming back from the West Coast with a chap from South Africa who tells me that they are having

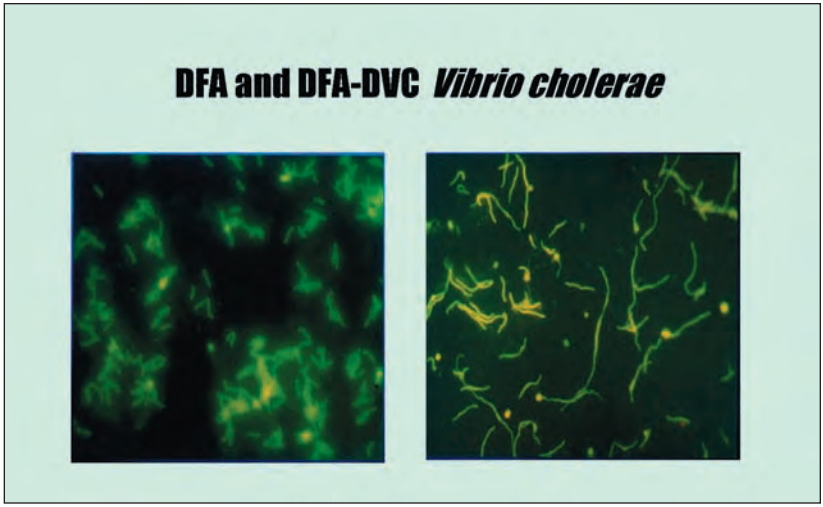

Figure 32. DFA and DFA-DVC Vibrio cholerae. *Source: Author.*

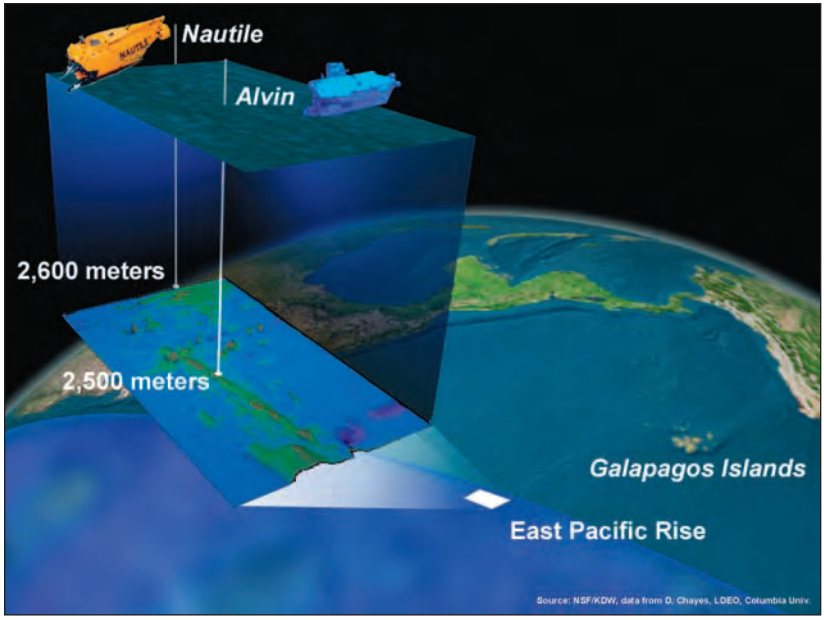

Figure 33. Pacific Study Area. *Source: NSF/KDW, data from D. Chayes, LDEO,* Columbia University.

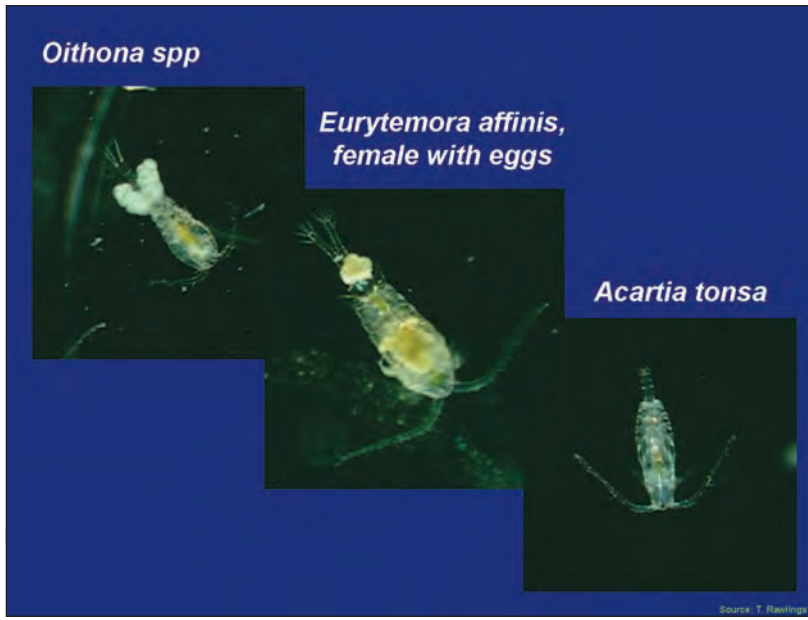

Figure 34. Copepods. *Source: T. Rawlings.*

cholera outbreaks in South Africa near the Zimbabwe border. So this is a disease that we need to understand more about.

Twenty years ago, my students and I showed that the disease bacterium exists in all estuaries, including the Chesapeake Bay. Of course, at that time, this was not a popular thing to publish. In fact, I must say that National Marine Fishery Service cut off my funding, saying I was giving fisheries a bad name, but fortunately the Sea Grant College Program gave me ten times as much money to continue the work.

The point is that the tools of molecular biology allow us to track these organisms. Here I show a flourescent monoclonal antibodies staining of an organism when it's very difficult to isolate it from the environment, but we can detect it, similarly with gene probes. We can determine that, in fact, they're alive, as you can see on the right-hand side. Adding some antibiotic and some nutrient, they begin to expand and lengthen. The organisms, even though you can't grow them in the lab, are very much alive. They go into a dormant stage.

So these bacteria are associated with plankton. They have a very specific commensal or perhaps even symbiotic relationship with these critters. Why is that important? It's because it's a very specific relationship with eurytemora, acartia, the plankton species found in estuaries throughout the world.

We made an interesting discovery, and this is important because it also impinges on what I want to tell you about the anthrax story. In a dive to the East

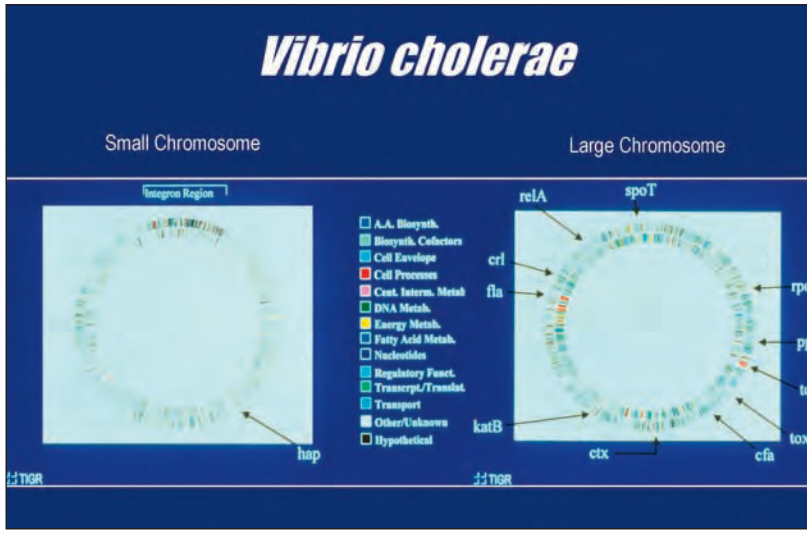

Figure 35. Vibrio cholerae Chromosomes. *Source: The Institute for Genomic Research.*

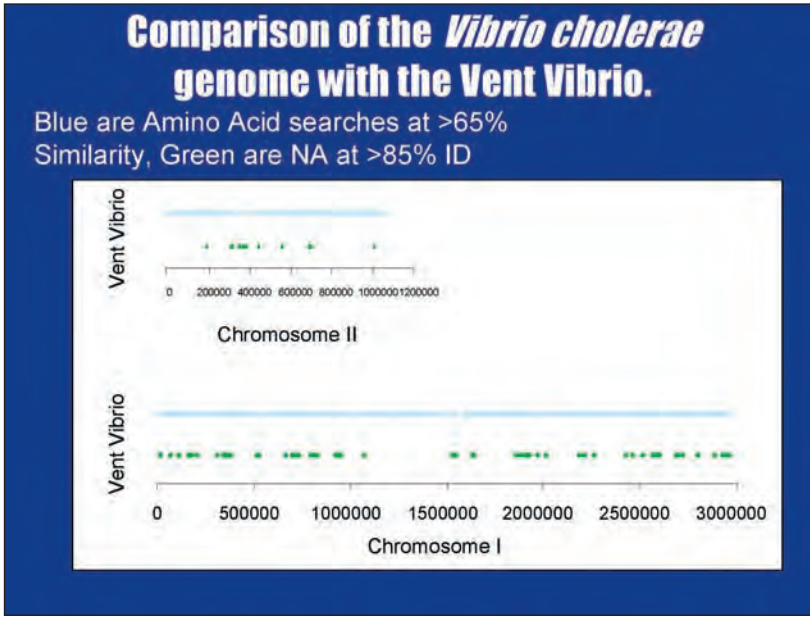

Figure 36. Comparison of the Vibrio Cholerae genome with the Vent Vibrio.
Source: Author.

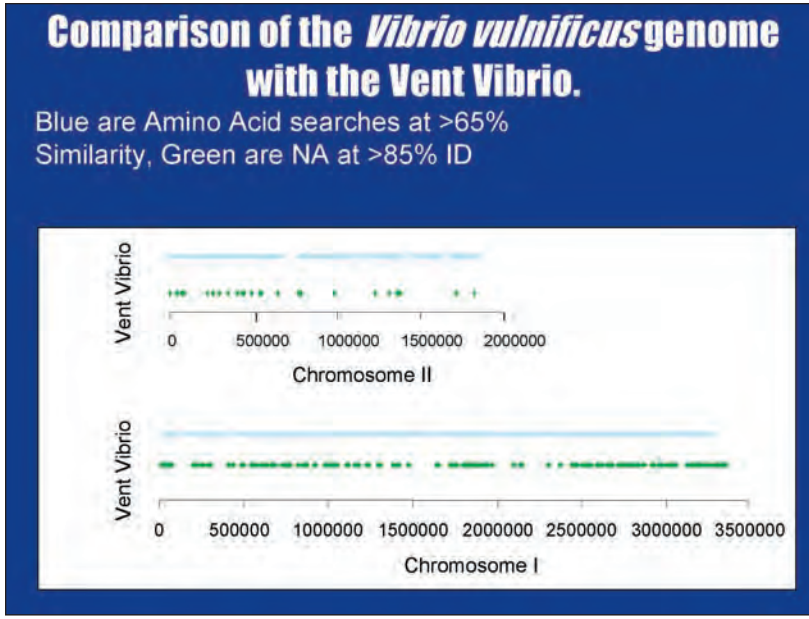

Figure 37. Comparison of the Vibrio vulnificus genome with the Vent Vibrio. *Source: Author.*

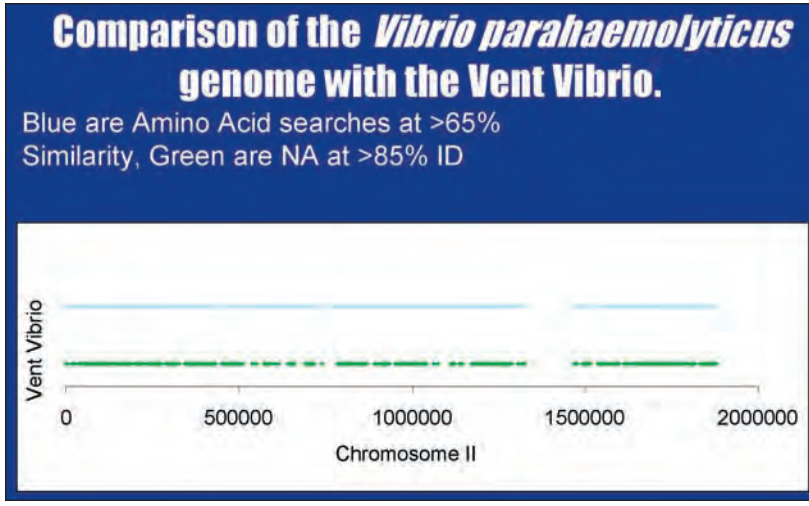

Figure 38. Comparison of the Vibrio parahaemolyticus genome with the Vent Vibrio. *Source: Author.*

Pacific Rise to one of the hydrothermal vents we found copepods, and indeed we were able to pull up samples from about 1,800 meters beneath the surface and isolate a bacterium that is very similar to vibrio cholera. Here are the two chromosomes of vibrio cholerae, and when we compare the vibrio from the vents, which look very much like them, we can see that the green or the nucleic acid similarities, the blue of the nucleic, the amino acids, represent similarities of this deep sea vibrio with this very powerful infectious agent of humans.

Similarly, another very important infectious vibrio has many nucleic acid and amino acid similarities to the deep sea bacterium, as does vibrio parahaemolyticus parahaemolyticus, the major cause of food poisoning in Asia, and for the first time, cases occurred in Seattle and Alaska because of warming of the waters in those areas. We had about a hundred victims of vibrio parahaemolyticus a few weeks ago in Seattle.

So these are changes that are occurring in the environment that affect infectious diseases. The background of knowledge that we must have is critical in order to be able to pinpoint when and where an outbreak is bioterrorism versus the naturally occurring.

Now my comment about anthrax is that we did the very same analysis. As Director of NSF, I was able to have funded immediately the sequencing of the

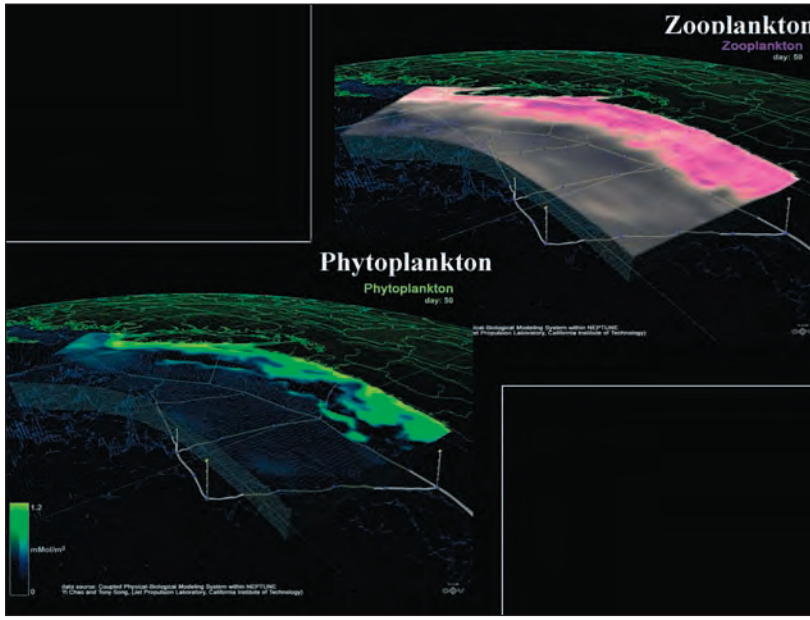

Figure 39. Location of Phytoplankton and Zooplankton. *Source: Coupled Physical-Biological Modeling system within Neptune: Yi Chao and Tony Song (Jet Propulsion Laboratory: California Institute of Technology).*

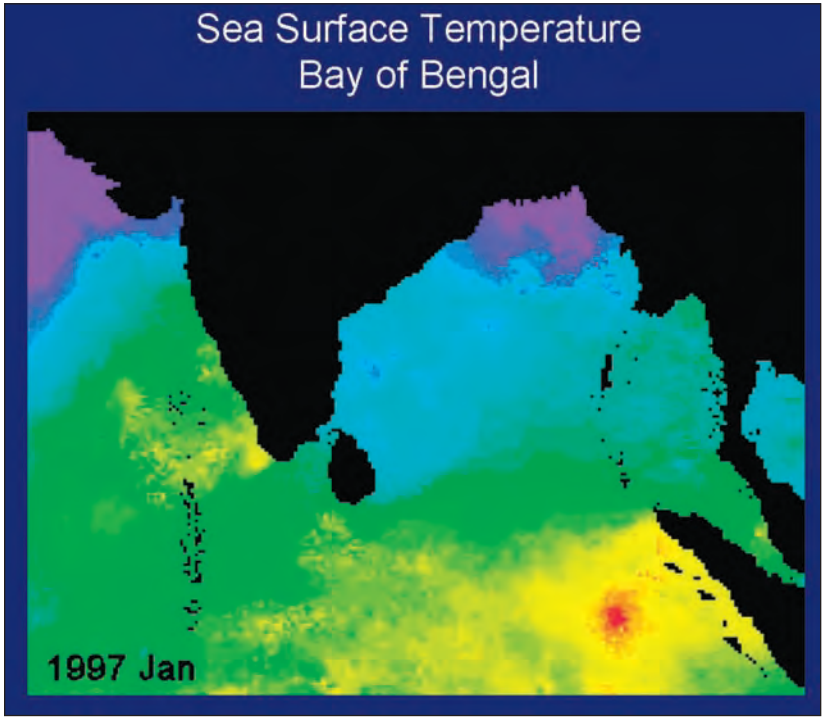

Figure 40. Sea Surface Temperature, Bay of Bengal. *Source: B. Lobitz, U.S. NASA, Ames Research Center, Life Sciences Division.*

bacterium, the anthrax bacterium that killed the chap in Florida. Since then we have sequenced 17 or 18 strains of anthrax.

We have been able to detect a very significant sequence that allows us to pinpoint its origin, and as you read in the *Washington Post*, now they've widened the search because the preparation was one that a very talented microbiologist who knows how to work with anthrax could prepare. So I think that with the sequence signature, this has allowed us to track much more precisely the source of the organism.

Fortunately, since 9/11 I have led an interagency team that has worked on obtaining the sequences of all the Class A, Class B, and even the economically important pathogens. So in August we published a compendium of all of the smallpox sequences, and we now have signature sequences within the smallpox sequence. This is a tool that is incredibly valuable and very important in our battle in bioterrorism.

What I want to emphasize is that phytoplankton blooms occur first when there is a warming with the spring weather followed by zooplankton blooms, which graze on the phytoplankton. The zooplankton are sort of like the microscopic cattle of the sea. They graze on the plants.

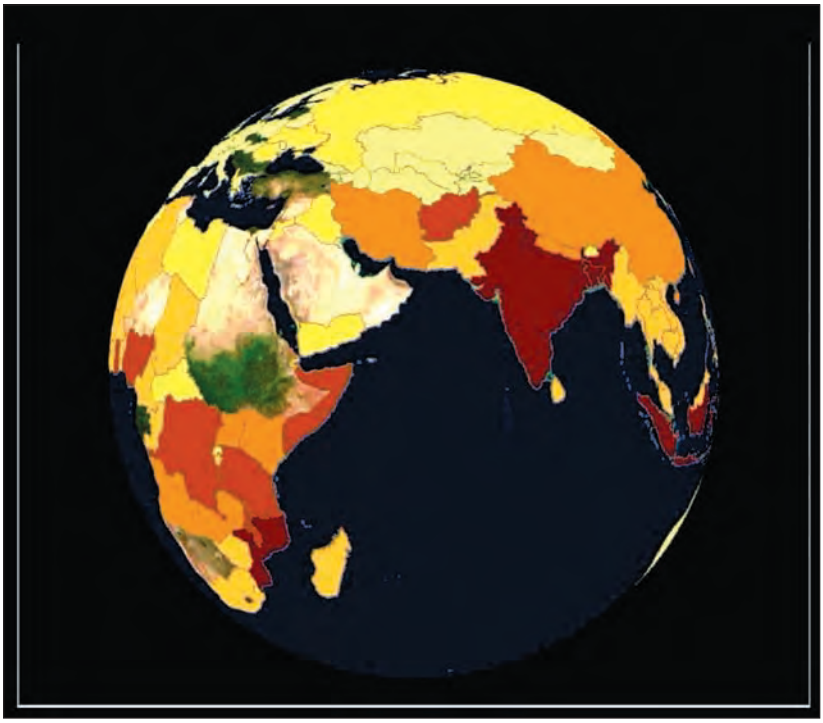

Figure 41. Incidence of Cholera in the Eastern Hemisphere. *Source: Author.*

The El Niño events are also very important in understanding cholera and massive epidemics that might be misinterpreted as perhaps a bioterrorism event. The sea surface temperature has proven to be a very powerful predictor for us.

Let me take you to the countries where the cholera cases occur. The darker shading means the more serious the epidemics and the larger numbers of cases. Peru had a massive epidemic in 1991-92, which we were able to trace to an El Niño warming of the surface waters. But the home of cholera is really in Southern Asia, Indonesia, and especially India and Bangladesh. And Bangladesh is a country on the Bay of Bengal, with an extensive river system and flood plain that is an important resource for the nation.

More importantly, let me take you to Mautlau, an area that was first a Southeast Asia treaty organization laboratory, and for the last 40 years it's been an international laboratory that has allowed us to obtain data on the families living in this—I guess you would call it a kind of county. It's a *taua* in Bangladesh, and you can see the red areas, the dots, are the hot spots of cholera, but the blue are the ponds around which the houses are built.

Let me remind you that this is a country very susceptible to flooding, to the monsoon winds and rains and the nutrients coming in from the

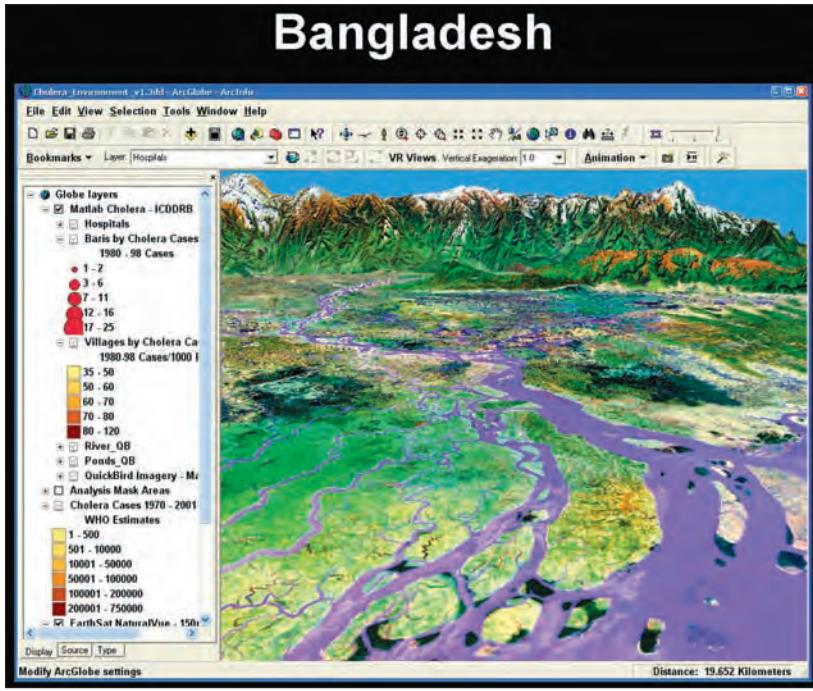

Figure 42. Cholera Environment—Bangladesh. *Source: Author.*

monsoons that come up toward the Himalayas, and the winds drive the tidal portion of the Bay of Bengal up into the rivers, seeding the plankton in the rivers of Bangladesh.

The homes of Bangladesh here are typical of the Third World, and a cholera victim being carried by her husband to the hospital during one of the worst monsoons two or three years ago, and the typical cholera cot still used today, measures the volume of fluid lost by vomiting and diarrhea, and if it's not replaced, death ensues within 24 hours. You can be fine, but 24 hours later, you could be dead, simply because of the loss of the fluid, then a systemic sodium-potassium imbalance, systemic shock, and death.

We were able to link very clearly cholera cases and sea surface temperature. You can see how sea surface temperature and the lighter dotted line representing sea surface height, precede the cholera epidemics. I'll have more to say about that in a minute. 1997-98 gave us a human experiment. That is, it was predicted by the climatologists there would be an El Niño in 1997-98, so we brought our colleagues from Colombia, Mexico, Chile, Peru, Argentina, Brazil, and Costa Rica to Baltimore for training in the use of molecular tools.

The team gathered in Baltimore. We trained them in the molecular tools, and we were able to show very clearly that in 1997-98, they could pick up,

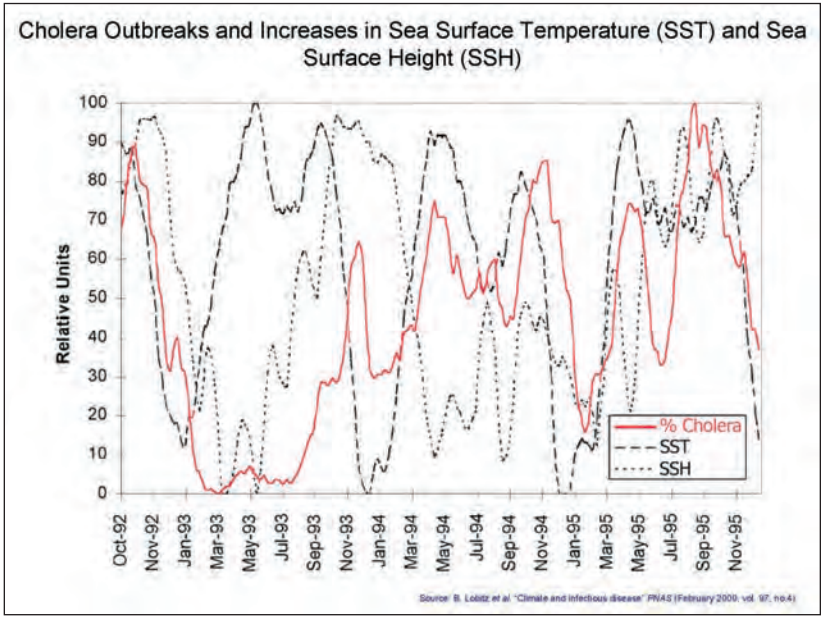

Figure 43. Cholera Outbreaks and Increases in Sea Surface Temperature and Sea Surface Height. *Source: B. Lobitz et al. "Climate and infectious disease" PNAS (February 2000, vol. 97, no.4).*

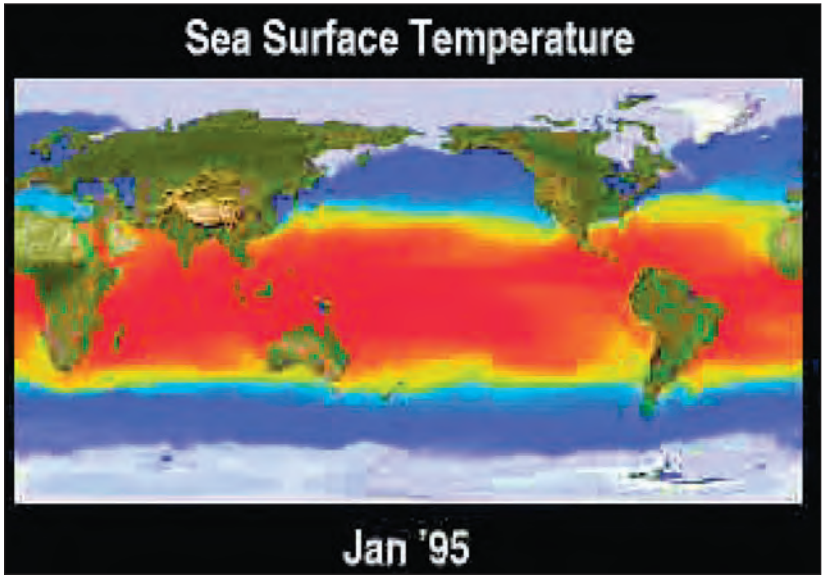

Figure 44. Relative Sea Surface Temperatures. *Source: NCAR Computing Division.*

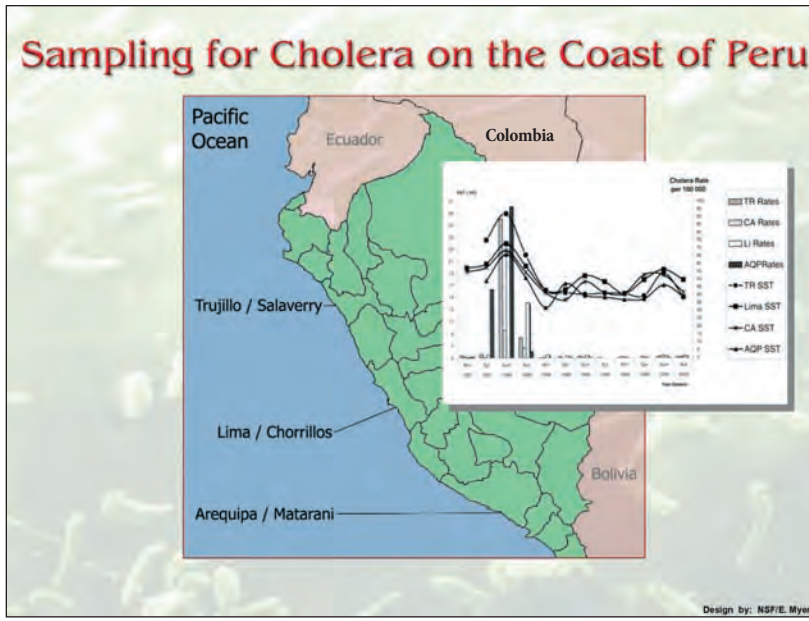

Figure 45. Sampling for Cholera on the Coast of Peru. *Source: NSF/E Myers.*

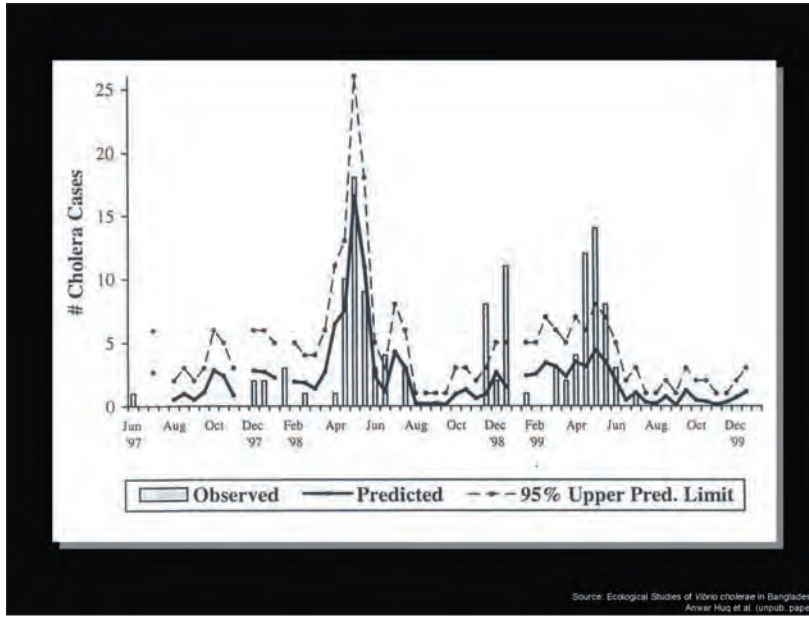

Figure 46. Observed and Predicted Cholera Cases in Bangladesh. *Source: Ecological Studies of Vibrio cholerae in Bangladesh, Anwar Huq et al. (unpub. paper).*

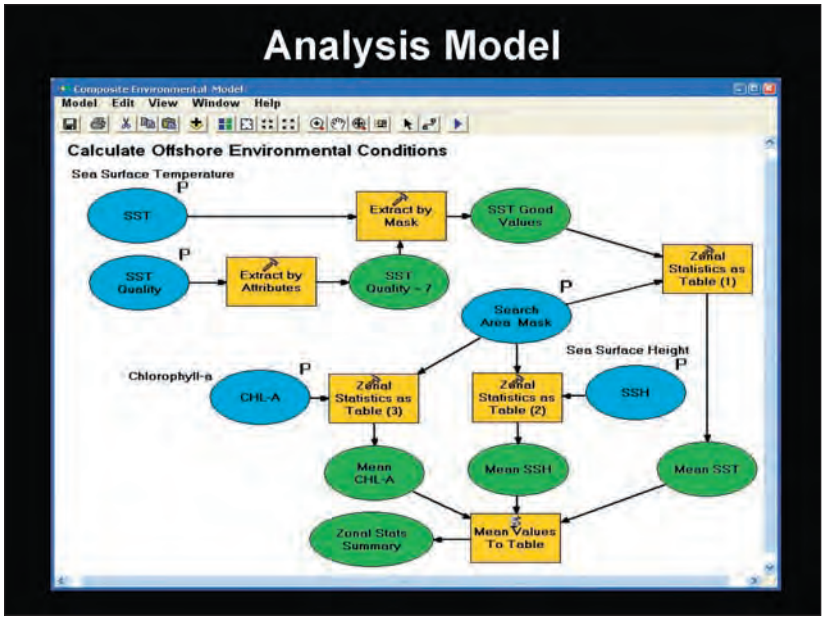

Figure 47. Composite Environmental Model for Calculating Offshore Environmental Conditions. *Source: Author.*

in September, October, November, by using these molecular tools, the presence of the bacteria in the water. The numbers became much greater by November, which is of course, their summer, and then cholera cases began to occur.

So we were able to preemptively understand, and predict what would happen, and we have the data that we've published that show these bars as the cholera cases in Trujillo, Lima, and Arequipa during the 1997-98 cholera epidemics that occurred.

We've taken all of these data from Bangladesh, from Peru, from other parts of the world, and we have been able to develop a very powerful predictive model. We now can predict for Bangladesh cholera cases. The dotted line is the 95 percent upper predicted limit, and you can see how rather closely the bars of the actual cases fit in within the prediction.

Working with ESRI, the group that does the GIS and GPS, we developed a much more sophisticated model shown here, and we used the data from 1998 to 2002 of cholera incidents in Bangladesh. These are the actual data, and then we plotted data from satellite imagery that gave us sea surface temperature. Satellite sensors gave us sea surface height. The sensors gave us chlorophyll measurements in the ocean in the Bay of Bengal. When you overlay them, they look a little complicated, but as I told you, there's a time lag. You correct for the time lag, and you get a very, very good correlation.

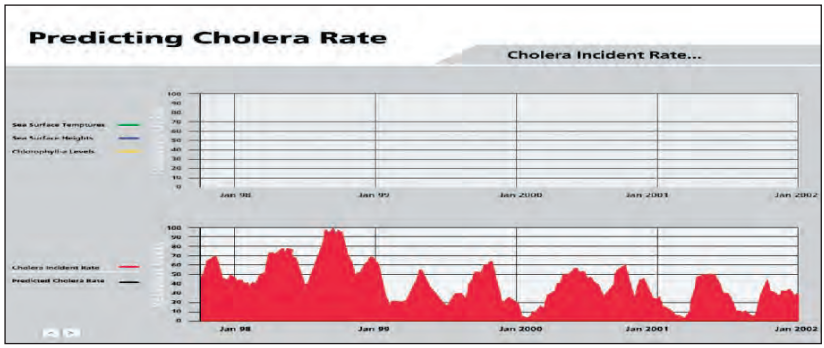

Figure 48. Cholera Incident Rate. *Source: Author.*

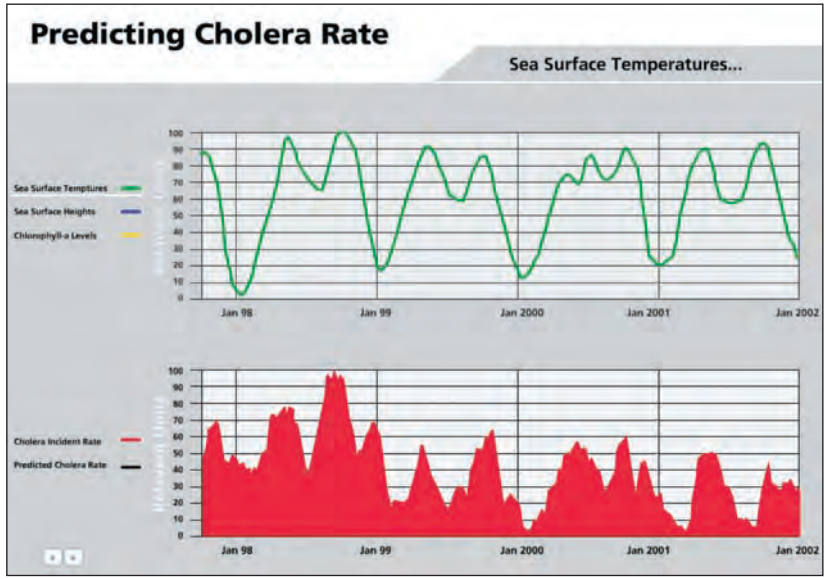

Figure 49. Sea Surface Temperature. *Source: Author.*

We asked ourselves, "Could we predict for June and May of the previous months, just from the environmental data, from the satellite data?" We did the calculations, we determined what the rate would be for those months, and then we e-mailed the hospital in Bangladesh and asked what the rates were.

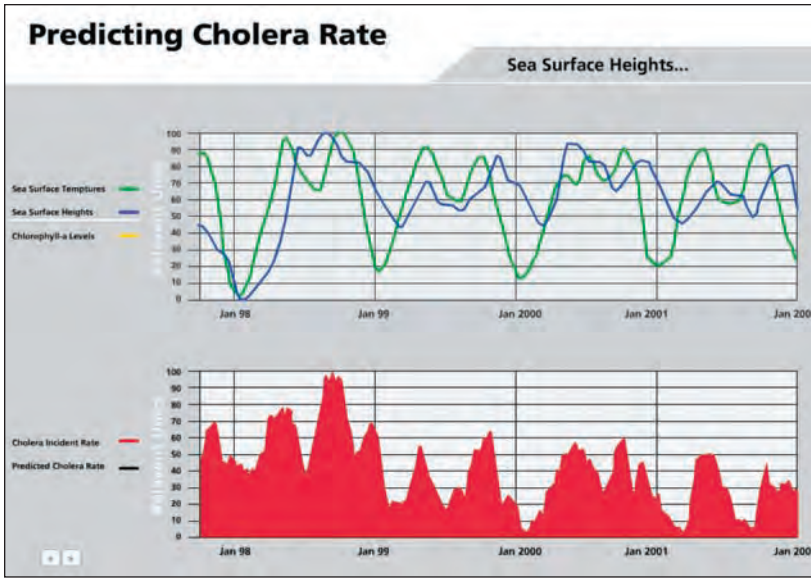

Figure 50. Sea Surface Heights. *Source: Author.*

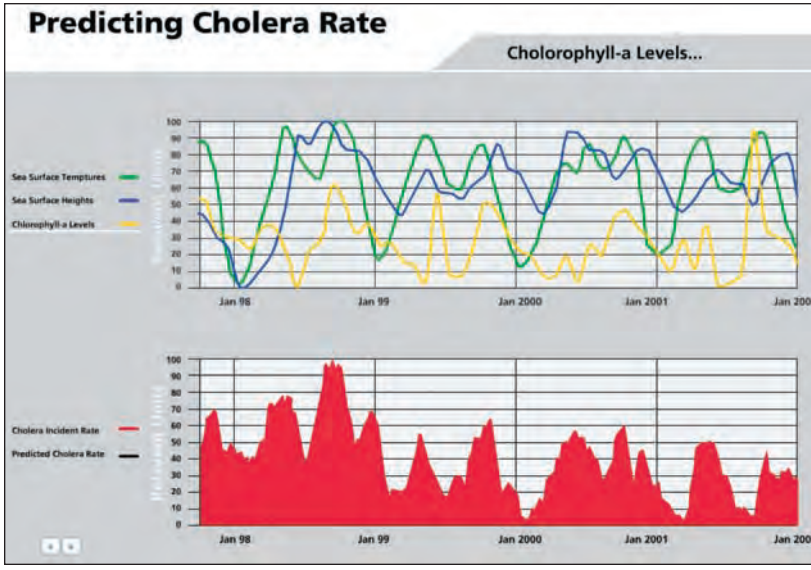

Figure 51. Chlorophyll-a Levels. *Source: Author.*

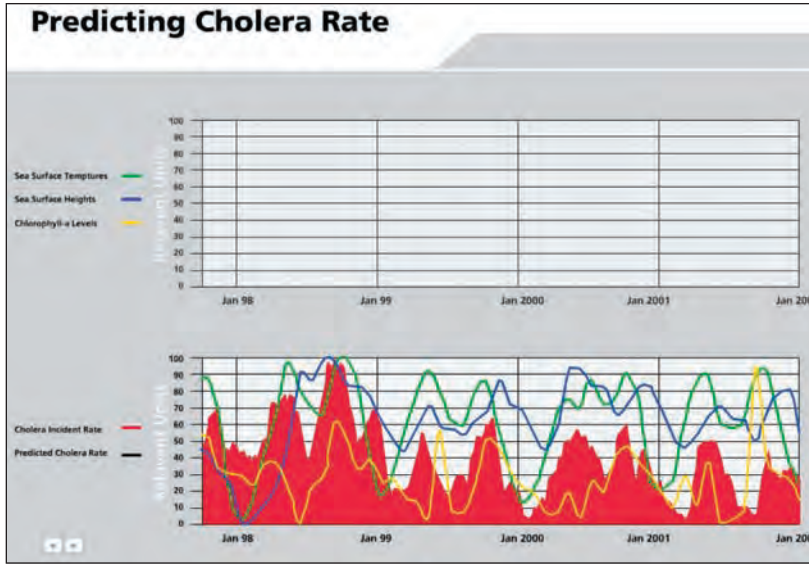

Figure 52. Composite Data. *Source: Author.*

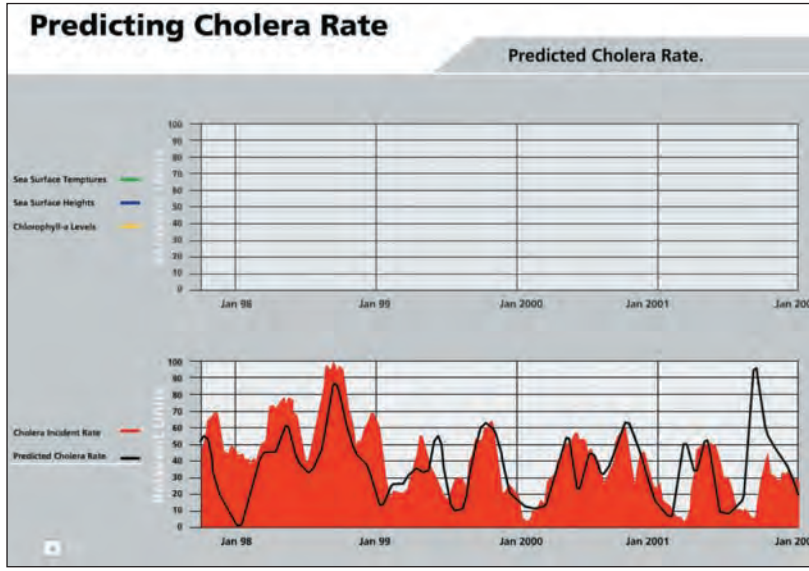

Figure 53. Predicted Cholera Rate. *Source: Author.*

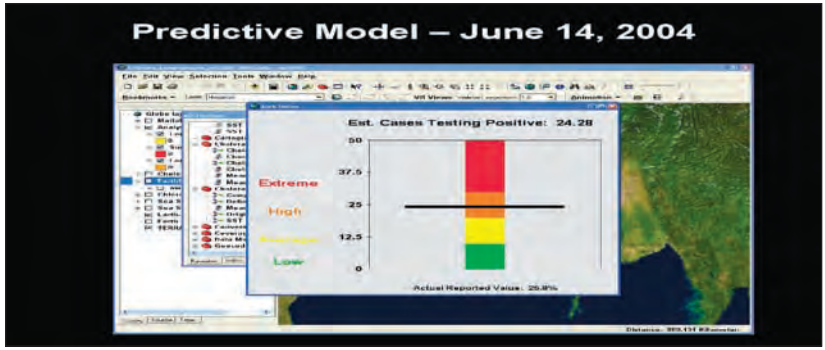

Figure 54. Predictive Model – June 14, 2004. *Source: Author.*

Figure 55. Using a Sari Cloth Filter in Bangladesh. *Source: Author.*

We were able to show that our predicted rate was about 25.8% of the cases coming in would be cholera, and the actual amount was 24.3%. So we now can predict when, where, and how intense these epidemics will be.

Now let me go forward. We put this to good use. The hypothesis was that it was the plankton, the particulates, that carried the bacteria. If we could remove it from the water, we could prevent cholera. So with funding from the National Institutes of Health, a three-year study was done involving 150,000 people, 52 villages, those that were filtering and educated by extension agents, which we paid to go out and train, those who filtered, and those who did not.

This is a very simple technique. Women wear Sari cloth. The old sari cloth was best, because it had smaller holes, and, in fact, we found that by electron microscopy, it gave us a 20-micron filter for mesh size. So we educated the women to fold the sari cloth four or five times, and filter the water before they use it. We are able to reduce cholera by 50 percent.

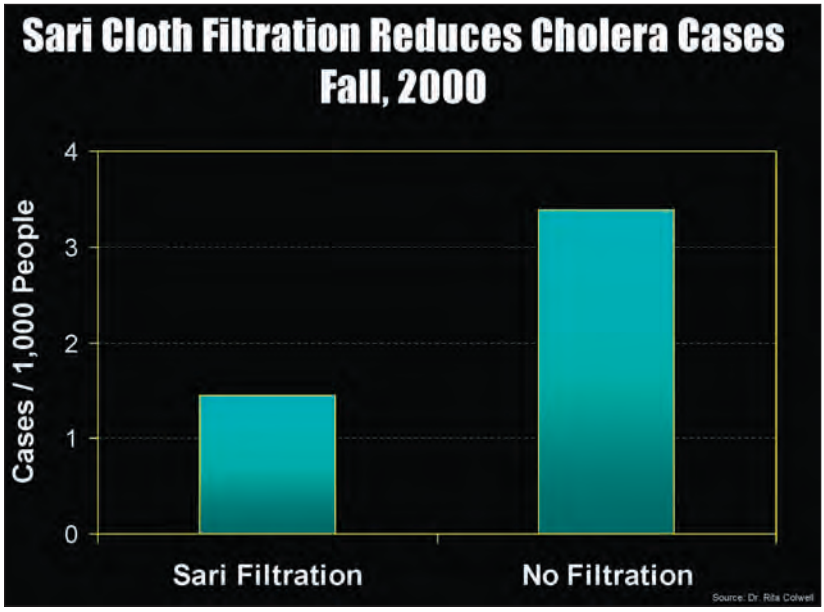

Figure 56. Sari Cloth Filtration Reduces Cholera Cases in Fall, 2000. *Source: Author.*

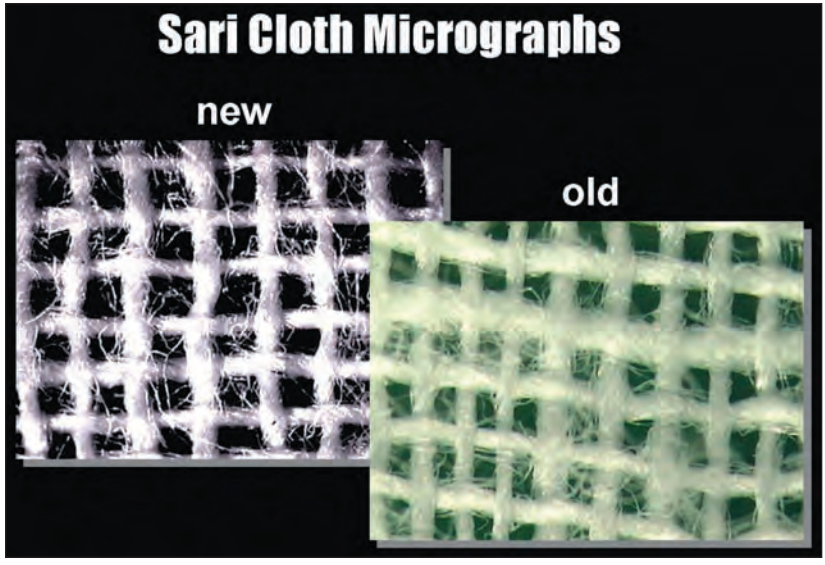

Figure 57. Sari Cloth Micrographs. *Source: Author.*

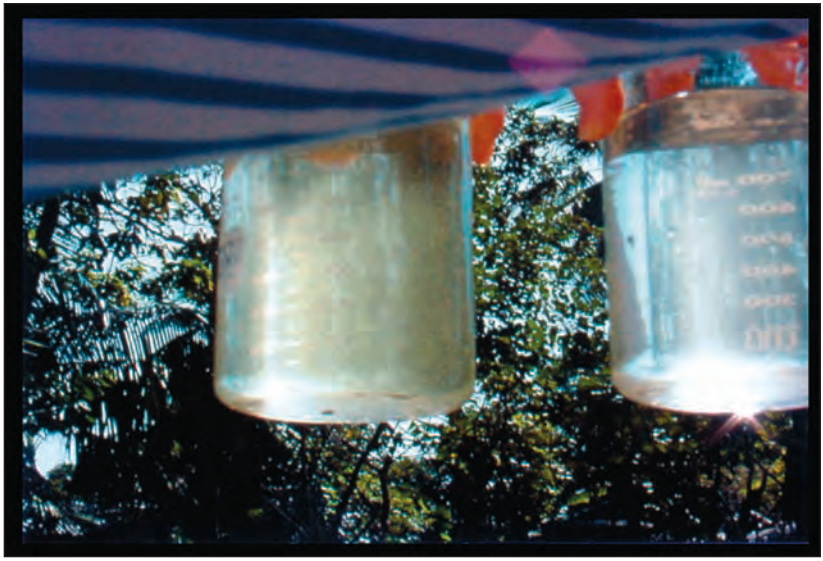

Figure 58. Container on Right is Filtered Water, on Left is Unfiltered. *Source:*

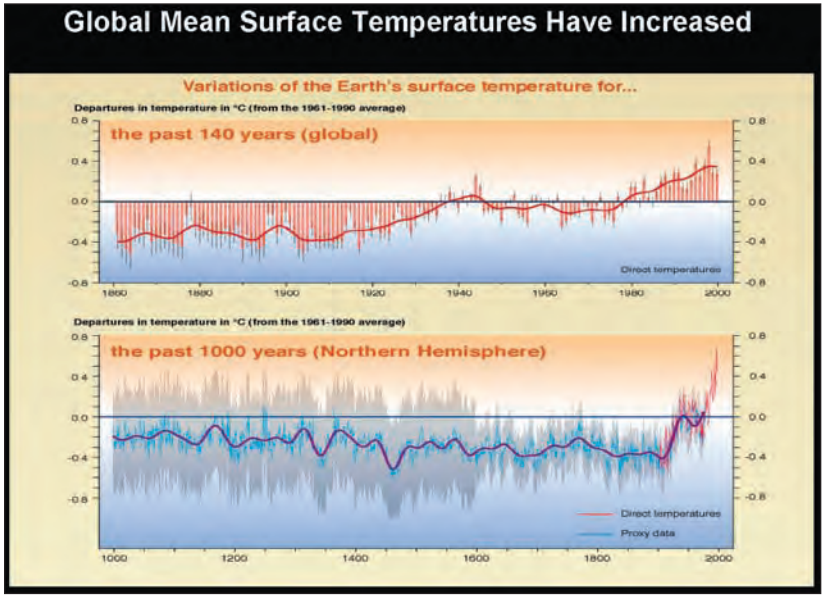

Figure 59. Global Mean Surface Temperatures. *Source: Intergovernmental Panel on Climate Change.*

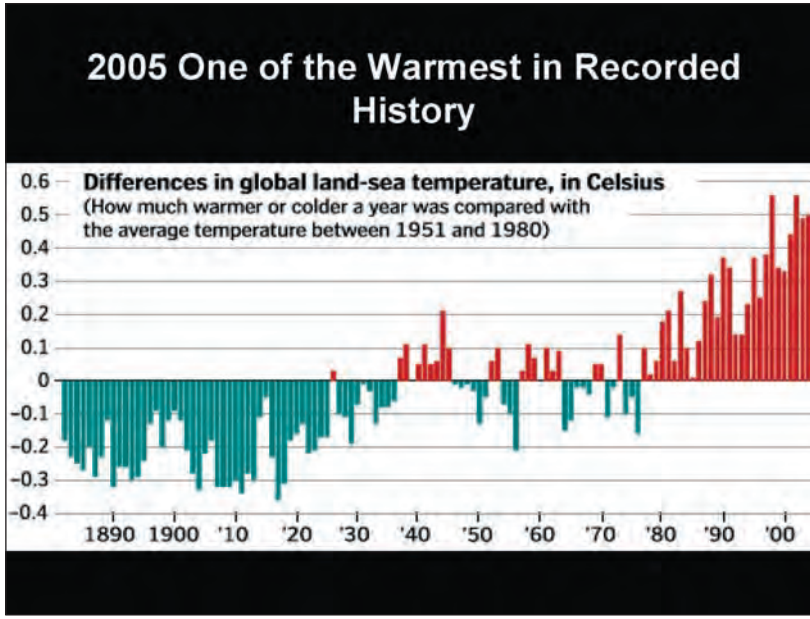

Figure 60. Differences in Global Land-Sea Temperatures, in Celsius. *Source: Goddard Intstitute for Space Studies, graphic originally published in Washington Post, December 16, 2005.*

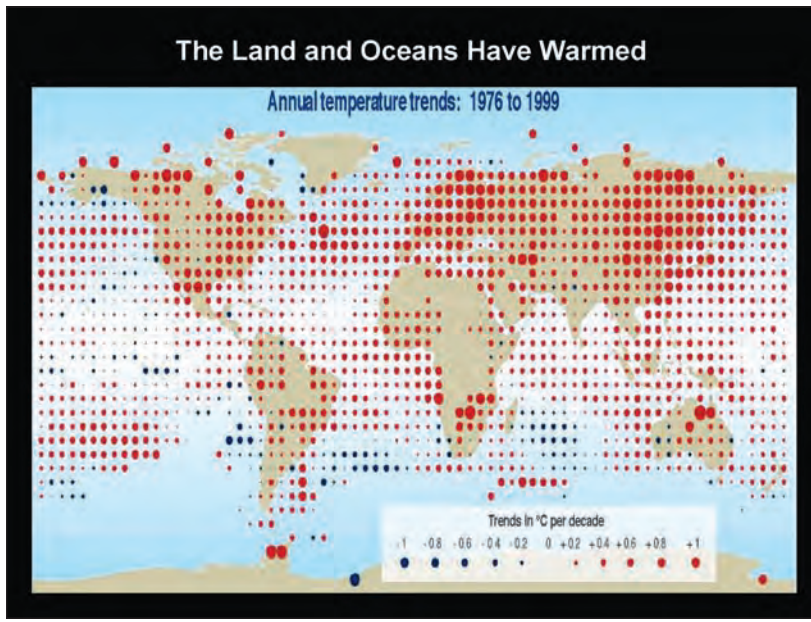

Figure 61. Annual Temperature Trends : 1976 to 1999. *Source: Intergovernmental Panel on Climate Change.*

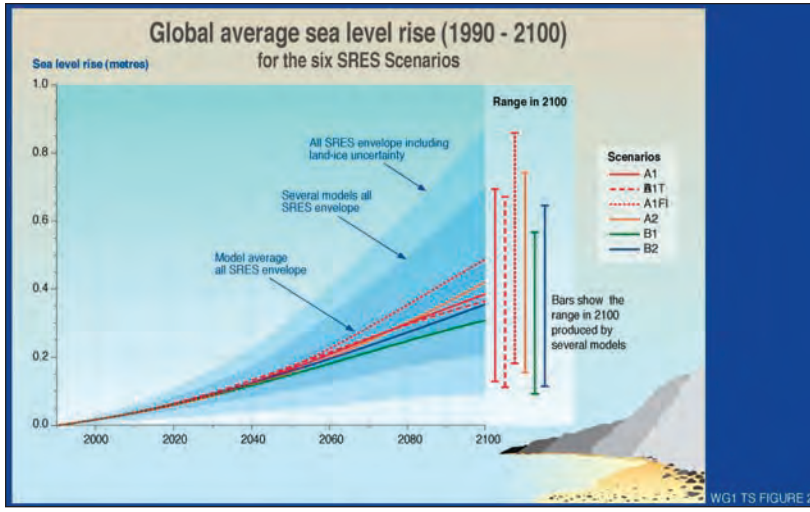

Figure 62. Global Average Sea Level Rise Estimates, 1990-2100. *Source: Intergovernmental Panel on Climate Change.*

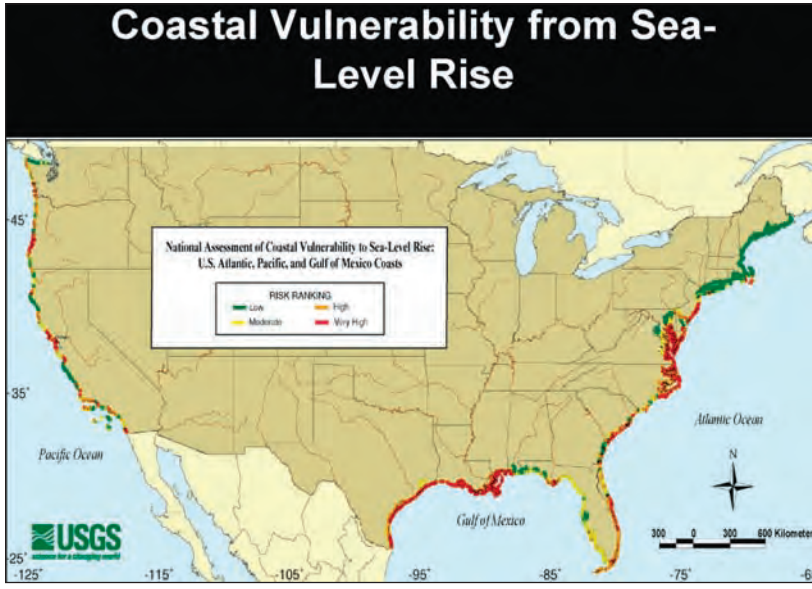

Figure 63. Coastal Vulnerability from Sea Level Rise. *Source: United States Geological Survey.*

Figure 64. Results of Six Meter Sea Level Rise. *Source: Image created by Jonathan Overpeck and Jeremy Weiss, courtesy University of Arizona Department of Geosciences Environmental Studies Laboratory.*

Of the cases that occurred of those who filtered, we found that most of them had gone to villages where they didn't filter, drank water, and got cholera. And of some of the cases where they did filter, because we don't trap all the bacteria, the cases were very mild, because it's a dose-dependent disease. You need about a million per teaspoon of water of the bacteria to get the infection.

This is very important for the military, for areas like Rwanda, for Somalia, where you have no chlorination, no central purification plant and outbreaks of cholera, a simple technique like this introduced to the villagers or even for

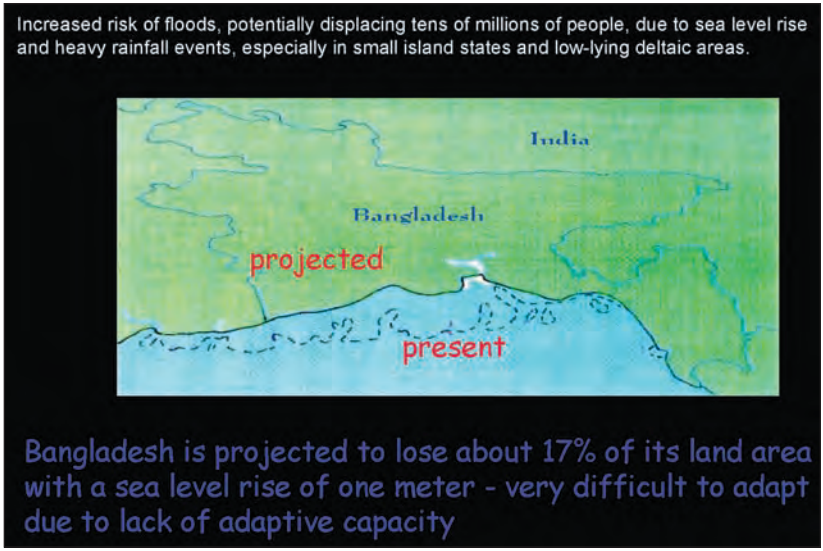

Figure 65. Projected Shoreline Change in Bangladesh. *Source: Author.*

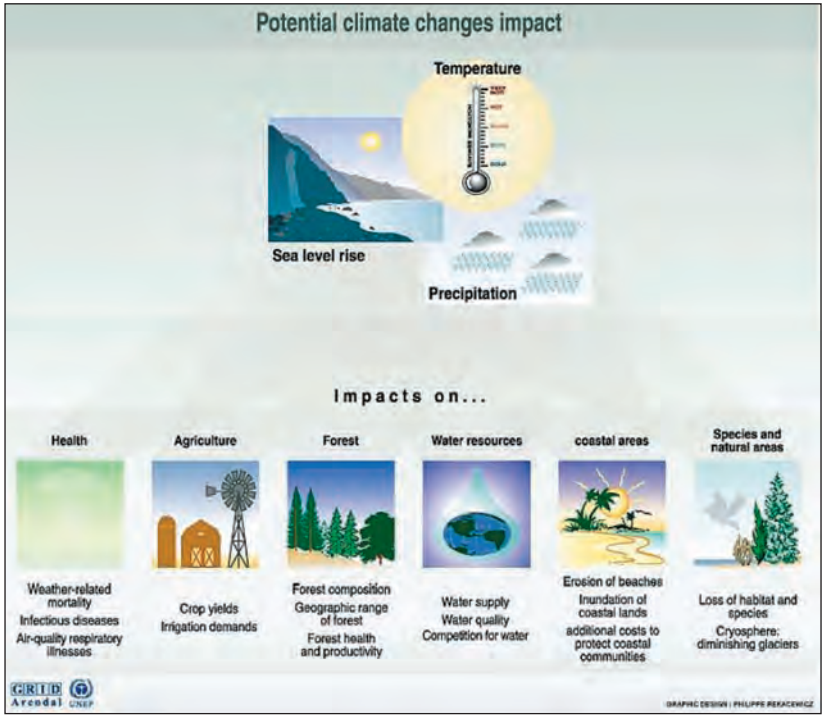

Figure 66. Potential Climate Changes Impact. *Source: United States Environmental Protection Agency. Graphic design by Philippe Rekacewicz.*

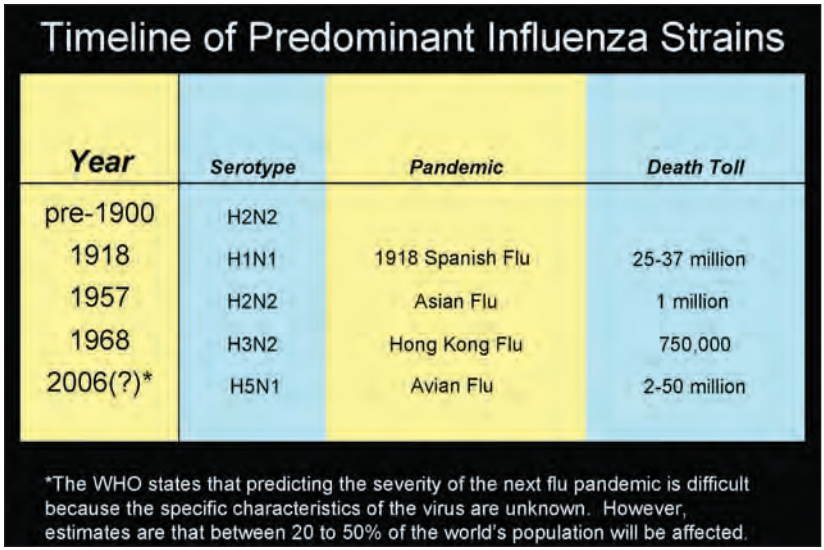

Figure 67. Timeline of Predominant Influenza Strains. *Source: Webster RG and Kawaoka Y, Seminars in Virology 5*, 103-111, 1994. *http://www.who.int/csr/disease/influenza/preparedness2004_12_08/en*

soldiers who find themselves without water and have to drink from the local sources, that kind of simple filtration can be effective.

Now, as I said, the old Sari cloth is better, because it's frayed, and it doesn't take much to convince anybody that the flask on the right-hand side on the chart, which is relatively clear, compared to the one on the left, is safer to drink. The stuff on the left actually—you can see it's swimming. It wasn't hard to convince the women that that's what made your kids sick.

Now let me talk a little bit about the global climate situation. I'm not going to argue about who's causing it. I don't really care. I think the point right now is what do we do about the situation, and what do we do to be not met by surprise. 2005 was the warmest in recorded history. Glaciers are retreating. This is Switzerland in 1930, 2001, and this is Alaska in 1950 and Alaska in 2001, so we do have warming of the land and the oceans.

What does this mean? You could calculate from the models of the sea surface rise, and taking the most conservative and not the most exotic, these are the areas which are susceptible to sea level rise. The red is very high. The orange is high. Yellow is moderate, and green is low risk. However, this is what Florida would look like if we have that six meter sea level rise. Similarly, Bangladesh would lose perhaps a third or at least 25 percent of its country, totally flooded.

So this is a kind of climate surprise that we need to think about, as Tom Friedman said, it is to be "expecting the unexpected", and what, then, would

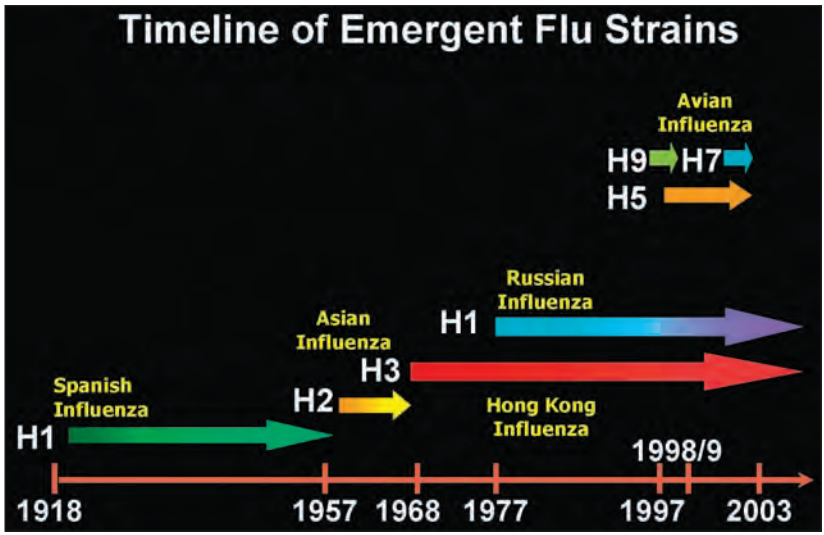

Figure 68. Timeline of Emergent Flu Strains. *Source: www.ama-assn.org/ama1/pub/upload/mm/36/2004_flu_cox*

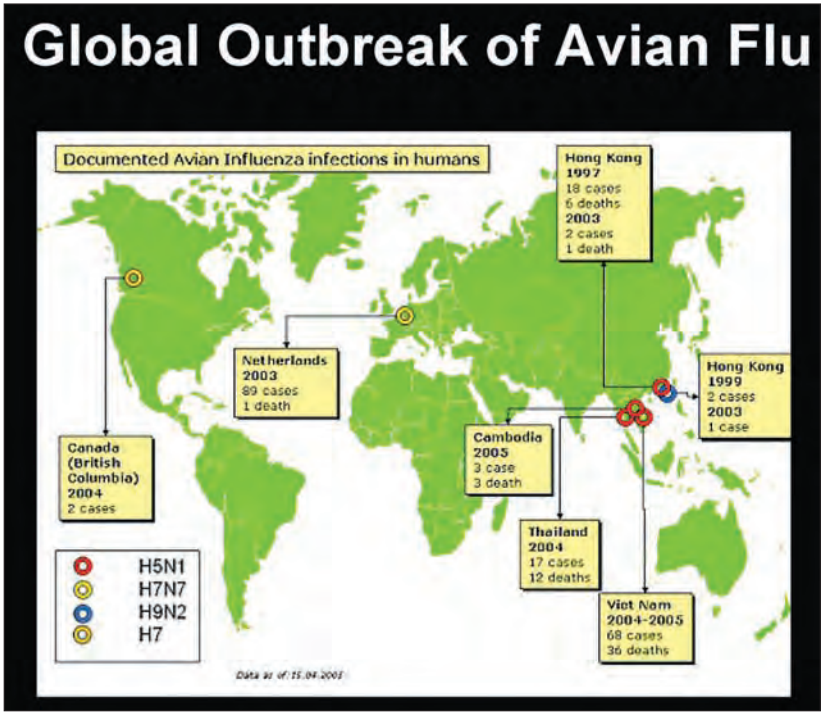

Figure 69. Global Outbreak of Avian Flu. *Source: World Health Organization http://www.who.int/csr/disease/influenza/H5N1-9reduit.pdf*

Reported Cases of H5N1 Outbreak

County	Onset of first reported case	Onset of last reported case	# of cases	# of deaths*
Viet Nam	December 2003	November 2006	91	42
Thailand	January 2004	November 2006	22	14
Cambodia	January 2005	March 2006	6	6
Indonesia	July 2005	March 2006	32	24
China	October 2005	April 2006	18	12
Turkey	December 2005	January 2006	12	4
Iraq	January 2006	January 2006	2	2
Azerbaijan	February 2006	March 2006	8	5
Egypt	March 2006	April 2006	12	4
All	**December 2003**	**April 2006**	**203**	**113**

*The number of deaths is included in the number of cases

Source: http://www.who.int/csr/outbreaknetwork/en

Figure 70. Reported Cases of H5N1 Outbreak. *Source: World Health Organization http://www.who.int/csr/outbreaknetwork/en*

ensue. These are some of the effects of health, agriculture, forest, et cetera, but infectious disease, I think, is critical for us to understand.

It's not that we'll have more cholera, but we'll have regions more susceptible to cholera and malaria. Malaria and most every vector-borne disease will be reactive to warmer temperatures, so we'll have longer seasons, and we'll have geographical areas more susceptible to the infectious diseases.

Let me talk a little bit about flu, and then I will close. The Spanish flu killed about 25 to 37 million people. The Asian flu in 1957 killed about a million people, and every year with just ordinary, run-of-the-mill flu, 36,000 people die. The prediction for the avian flu, if it jumps from birds to humans in a way that is very, very transmissible, is that we could have anywhere from 30 to 100 million deaths worldwide.

This graph shows—this is the work of Steven Salzburg, a colleague of mine at the University of Maryland who has sequenced about 350 influenza viruses, the emergence of the H-1 factor, the hemogluten and one of the factors associated with its pathogenicity. And you can see there's a time lag where these genetic jumps or mutations occur.

This is an old map. It shows some of the countries that have recorded at least birds carrying the avian flu. The more recent data, which I got from

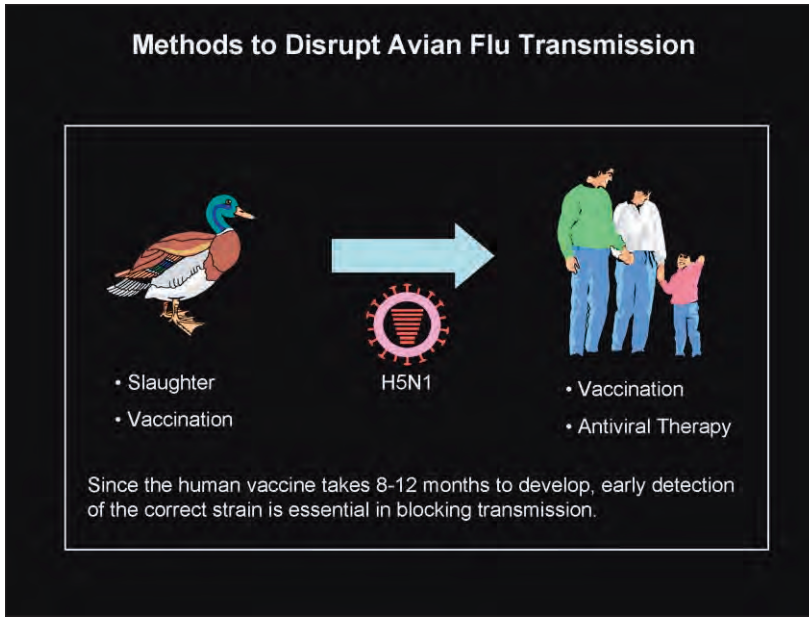

Figure 71. Methods to Disrupt Avian Flu Transmission. *Source: Author.*

Steven just a few days ago, shows that as of 2006, 203 cases and 113 deaths have occurred. It has a mortality of about 50 percent, and, unfortunately, it attacks the young between the ages of 15 and 35, and that is hypothesized to be a result of the very strong and powerful immune response that occurs that essentially causes flooding of the lungs and death from asphyxiation.

The only protection we have is to slaughter the birds, and billions of birds have been slaughtered in China and Laos, Cambodia, and vaccination, and we've been reading in the newspapers about where we are with the vaccine, both for anthrax and for the avian flu. Not too great. And the antiviral, there are a couple of them, and we discovered, though they didn't want to tell us, that the Chinese were actually vaccinating their birds, I mean, using the antivirals for their chickens, which means that resistance has developed.

So these infectious diseases are a moving target, and it is important that we have an international collaboration, international linkages of laboratories, and an understanding that it's interdisciplinary. It's mathematics. It's modeling. It's gene probes. It's molecular genetics, sequencing. It's understanding climate, climate variables, remote sensing.

This takes into account all of the intelligence agencies' components under the national intelligence director, and it is important that we have a coordinated, interdisciplinary, international approach to understanding infectious

Figure 72. Collaborators and Colleagues. *Source: Author.*

diseases to have that background, sort of like caustic radiation, the background, so that you know when that blip occurs that it is not normal and to be able to go in and to seek out the solutions.

So I just want to acknowledge many colleagues from Bangladesh, and from the International Center of Diarrheal Diseases Research, which included physicians, sociologists, social and behavioral scientists who are critical in understanding and protecting and preventing infectious diseases. It also included environmental scientists, students, post-docs, colleagues at NASA, NIH, from other countries, and from ESRI, the GIS/GPS folks.

So my message is, in this one world there is an interlocking health that's shared by all living beings that are dependent on the same environment. We need to integrate our health planning for human beings with that of our livestock, with our farms. The separation of human medicine from veterinary medicine is artificial, and we need to close that gap and also to understand from the conservationist the wild species that can serve as reservoirs or carriers of many infectious diseases.

Infectious diseases still kill more human beings than any other cause, and influenza ranks at the top. A smallpox pandemic could cause 50 million deaths. An influenza epidemic could kill hundreds of millions, and avian influenza is one of our threats.

Figure 73. More Collaborators and Colleagues. *Source: Author.*

So I would like to close by saying that this type of connectivity comes sometimes from unexpected quarters. Your threats and opportunities increasingly derive from who you are connected to, another observation by Tom Friedman. The global networks of air travel helped the disease SARS to hop across hemispheres, but the scientific networks of collaborators around the globe discovered the virus that caused the disease, and they did that in a few short weeks.

We find that scientists who collaborate are more productive than those who don't, and networking is revolutionizing medical diagnosis. Barabasi writes in his book entitled *Linked*, "We're seeing the cell as a whole, as a network, rather than as a bag of independent chemicals. Imagine walking into a doctor's office not too far in the future and being examined with a hand-held device the size of a credit card that'll diagnose the bacterium or virus causing your symptoms right on the spot," and that's what we're working on.

Complexity theory is also another important activity that we need to work on. So linking with social sciences to understand networking and seeking out the synergy of the many ways of knowing, we can cultivate the imagination to anticipate both the natural and the human instigated tsunamis of whatever kind that are being generated in some small way in some unnoticed place but that could ultimately grow to wash over the entire world. Thank you.

Finding the Will and Ability to Apply New Paradigms

Mr. Aris Pappas
Deputy Director of Microsoft Institute for Advanced Technology and Government.

I'm the Mr. on the list of notable doctors here, and I'm a practitioner. I'm not a technologist. I've never invented a technological solution or advance. It would be proof of life in outer space if I did something like that, but I've had any number of technological solutions inflicted upon me as a practitioner of intelligence work, and so it's from that angle that I want to speak to you today.

Mr. Aris Pappas addresses the Conference.

I've attended many sessions with titles like this one, not unlike this one, and they tend to focus on how technology can help the Intelligence Community. But mostly, in my opinion, they were examples of self-professed success. The technological sector would find something that they could do, and they would attach a metric to it, and then they convince the Intelligence Community or some other customer that this would be a good thing. It'll help you out. And it should, I think, be the other way around, as you'll see in my comments.

I haven't seen a great deal of material improvement in the quality of the overall intelligence process over the course of a very, very long time, and

you'll notice from the very beginning that I speak in terms of generalities. There are exceptions to absolutely everything that I'm going to say. So I'm the grinch at the party, and I'll ask in advance for your indulgence and hopefully for your serious consideration.

The principal problem for intelligence, defense, law enforcement, and the Department of Homeland Security is not technological. I have, naively, perhaps, complete faith in the ability of the technologists and scientists to resolve issues and to improve abilities to collect, analyze, and disseminate intelligence. But as we sit here today, that job hasn't been done, despite a mountain of rhetoric and bluntly worded directives, for example, one on information that I'll talk a bit about later.

My opinions as expressed here today are mine, not that of Microsoft or anybody else. My opinion is that the job's not done, because the simple will to do so remains absent. The hard problems facing the Intelligence Community are cultural and bureaucratic, and these remain to be addressed.

The events of 9/11 did not change the world. They awakened us finally to the reality that the world had already changed, but we had not changed with it. Let's take a quick look at the environment and the culture that we're working in and seek to improve. Intelligence was my chosen profession. In broad terms, my Intelligence Community, your Intelligence Community, was born—actually, I'm sorry—conceived in the fires of Pearl Harbor. It wasn't born until 1947 with the Defense Act.

It was designed specifically to do one thing. It was designed to look at the Soviet Union. It was focused overseas. My impression has always been this little statue with its little tootsies in the water facing out and looking overseas, and every time it tried to turn around and look over its shoulder, "Don't you do that. It's not right."

And then back to us was the FBI. They were standing there with their heels in the water looking this way, and if they turned around, somebody like the CIA would say, "Don't you do that. You look inside. We look outside, and never the twain shall meet." And how did we exchange information? It's very simple. [hand zero gesture] That's how we did it.

I cite to you examples like the Church Commission and so on and so forth for further evidence of the fact that culturally, bureaucratically, and sociologically, the entire structure of intelligence, defense, law enforcement, et cetera, was designed in this bifurcated fashion that absolutely caused us a problem.

The world changed with the fall of the Soviet Union, but we didn't. We did not change with it. We talked a lot about changing. I won't speak for DIA or the military, but CIA, we just went through study after study after study after study and reorganization after reorganization, but nothing really changed.

The way we did our business, the reason we did our business, and the way we focused on our business was really not adjusted in any significant sense. We were still looking for the next traditional threat. China looms, you know. Why? Because they've got stuff we can look at.

You laugh, because you know. Is that not right? We can look at it? Ipso facto, it's a metric. Metrics are the bane of our application of technology.

We looked at threats in the traditional sense. Only a few looked at radical Islam or, now, asymmetric warfare. It's not asymmetric weapons, by the way, that are the problem. Somebody said that earlier today. There are no asymmetric weapons. A bullet's a bullet. A gun's a gun. A tank's a tank. An airplane's an airplane. It depends on how many you have. It's the application of those weapons and the way they're controlled, applied, and planned. Those are the things that are asymmetric, not the weapons themselves. This is not a technological issue.

We absorbed blow after blow after blow. Barracks were being blown up. Ships were being blown up. Embassies were being blown up, and in my personal opinion, we would have gone on and accepted and absorbed that kind of damage forever until bin Laden made a gross strategic error by basically exceeding the norm and forcing us into a reaction that resulted in his loss of the Taliban, Afghanistan, and any number of changes in the world.

And that's not a political statement about how well anything is going or how badly anything's going in Iraq, Afghanistan, or elsewhere. It's just simply a fact that things changed when he did that, and they did not change necessarily in his favor.

9/11 caused us to recognize that the useful distinctions we placed on our definitions of the roles played by intelligence and law enforcement left exposed a serious gap in our defenses that bin Laden drove those airplanes right through. The immediate reaction, and I think it's fair to say most of the faces in this room would have been around for that, the immediate reaction, unsurprisingly, was all over the place.

Information sharing became a cause celebre. Remember? Fall, winter of 2001, information sharing. Well, what do we have to do? We have to integrate databases. FBI's got a database. Okay. CIA's got a database. Fine. Put them together. DIA's got a database. Well, we'll invent NONCOM, and we'll make a database.

Do whatever you want. We'll just put these things together, and we will find these dots, these mythical dots and connect them, as if this was some simple, rational problem in which a simple connection of known points in space would somewhere provide an answer.

Well, the roles of intelligence in law enforcement communities were carefully or, I would beg to say, maybe massively studied, and direct memoranda were done. I think it's okay to say that I saw one memorandum concerning

intelligence sharing that was signed off by no less than the DCI, the Attorney General, the Secretary of State, and the Director of the FBI, and I'd never seen a memo like this before, not simply because of the signatures, but because of the tone of the memo.

The memo said, "You will share this information," and it even went on, and I think it was relatively unprecedented. Some of you may have seen memos like this before, but in a way I considered unprecedented, it said, "And you can't use this excuse for not sharing it. You can't say that it's because of your collection. You can't say it's because it's an ongoing case. You can't say it's because it's source critical."

It actually went and predicted the inevitable bureaucratic result. Okay, it was the most powerfully worded memo along those lines I'd ever seen. Net result? That's not an "Okay." It's a zero. There are those of you who might be offended, and, you know, offending is not bad because it keeps you awake, and it embarrasses me when I see heads going down. But I don't mean to offend you, and I don't mean to say that there hasn't been progress.

What I mean to say is from 2001 to 2006, are we now in 2006 where you expected we would be 14 days after 2001? My answer to that is absolutely flat no. It's been stymied at every stop on the trip. We didn't really change the way we do business, and I mean to argue that the reason is a cultural resistance to collaboration, which is a basic instinct, and the bureaucracies, the DNI notwithstanding, are as deeply rooted as ever, maybe more.

9/11 was not seen as an admonition to change, but as an opportunity to validate longstanding opinions and approaches. What do I mean by that? It wasn't an opportunity for CIA and FBI to come down and say, "Maybe we really have to rethink how we do this." No, it was an opportunity for CIA, FBI—later DHS enters into it—DOD, to say, "I always knew this was going to happen, and here's how I would fix it."

And they all were in a race to get the money and the authority to get their institutionalized response presented as the one that was going to be used, and that is not collaboration. That is not a solution to a new problem. That is evolutionary thinking that takes you right back to what got you into this problem to begin with.

And it's not to say that the people who had these ideas were wrong or evil or had any kind of evil or bad intentions. Not at all. They were committed people, but no one grabbed this thing and said, "We've got to rethink this fundamentally."

I don't know what the military example might be, but after you've trained for 150 years to deploy the battle line in the Pacific, and you wake up on the 7th of December, and you find it's sinking in Pearl Harbor, you've got about 48 hours to figure out how to use aircraft carriers, and we did that. We did that,

and it wasn't something that we planned on necessarily, independent operations of task forces and task groups, but we made that adjustment, because we couldn't do what we wanted to do.

Unfortunately, 9/11 left us somewhat in a position of Kimmel and Short in that we were not left engaged. Why were Kimmel and Short removed and MacArthur not? MacArthur was engaged by the Japanese, and to remove a general who is engaged is a very difficult proposition.

Kimmel and Short were left there to look at their burning ships and airplanes, and so it was very easy to take them out, and bin Laden pretty much left us in that kind of situation, didn't he? We weren't really engaged. We just were running around trying to find something to do. So the bureaucracies are as deeply rooted as ever.

I went to a corporate function about a year or so after 9/11, and there was a very well spoken and, I think, highly motivated, well intentioned attorney from one of the lobbying groups for civil liberties. And he was making a presentation to this group concerning the dangers of the Patriot Act and so on and so forth, again, not getting into politics, not getting into are there dangers, are there not dangers, what is the nature of the dangers, and so on and so forth.

The fact of the matter was, though, that I had to speak after this gentleman, and what I asked the group was this. I asked all of these corporate executives had they heard anything new—this was very well received. You could see people nodding. They liked the presentation. It was good, but I said, "Did you hear anything from him that was any different than what you would have expected to have heard from him or his organization 60 days before 9/11?"

And all of the sudden you've got this sort of recognition. No, not one thing. Basically what they wanted to do was use this as an opportunity, finally, to get this done right, and everybody was running around trying to get that done. The problem is, it didn't work. The problem is that most of those plans and approaches were inherently evolutionary. They were based on old threats, old paradigms, metrics, and, I dare say, technologies.

Evolutionary change is a problem, because the systems and architectures involved are as dated and as focused as the bureaucracies that support them. The Intelligence Community, including the defense elements, were specifically designed to deal with a single prime target, the Soviet Union. Everything else was secondary. The target was ponderously slow and unbelievably predictable. You get some things wrong on a day-to-day basis, but over the course of decades, everybody knew what was going to happen. We were engaged in a high stakes Kabuki in which all the players knew their roles, whether that was in HUMINT or otherwise. Safest place to be, intelligence officer in Moscow. The Mafia couldn't hit you. The bad guys couldn't hit you. There were three KGB guys behind you, following you around to keep you safe.

You deny it? It was a Kabuki, the postures and limitations of which were all meticulously self-monitored, and that had to do with human operations, technical operations, and analysis. As an analyst, which is what I was at that time, everybody knew that you were in line to be the next one to either be the drafter of NIE 1138—how many people remember that? Anybody? 1138. That was a strategic one. That was the intercontinental warfare. Or 1114. Everybody remember that one? That was the one on theater forces and war in Europe. I always did 1114, because I figured 1138 was not a lot of fun, because if you were wrong, you'd never be around for the after-action report to find out what happened.

Our collection capabilities reflected the reality of that targeted approach. On the one hand, you could argue, and I think it would be justifiable in some context, to say that we had the Soviets wired for sound and light and any number of other things. On the other hand, the reality was, and this is something for professionals in an audience like this to recognize, and I know you do, was that we were really engaged in a massive game of statistical sampling.

We never, not one single day, from 1947 or 1940—pick your date—right through to the dissolution of the Soviet Union, we never on one single day of that entire period saw the entire Soviet military, let alone the Soviet Union. What we were doing was we were seeing enough of it to be able to credibly make the call, "There will be no war today," unless we're going to be attacked by some rogue regiment that's come out using its own barges, rode across the Pacific and attacked the Pacific Northwest.

We saw enough of an enormous target to be able to say that there is no way that that target is moving, preparing, or about to present itself as a threat to the United States. That's what we were in the business of doing—DIA, CIA, all of us. We saw enough to make our calls.

So both our collection and our analysis were viewed as absolutely precise and deeply penetrating, but really they weren't. They weren't as deeply penetrating as we had the impression that they were. They weren't as deeply specific and thorough as we gave ourselves the impression they were through metrics. We never, ever said or thought that we could account for the Russians or anybody else on a regiment-by-regiment, platoon-by-platoon or squad-by-squad basis. Never.

What are the problems of today? You know what my next sentence is going to be. They're significantly smaller than a regiment-by-regiment, platoon-by-platoon or squad-by-squad basis. The current threats are guy-to-guy, man-to-man, terrorist-to-terrorist, suitcase-by-suitcase, bomb-by-bomb.

We are not set up analytically, collection-wise, technologically or in any other way to deal with that kind of threat, and we're thrashing around trying to find ways to make these enormous statistical samplers somehow relevant

to a problem that simply is different. Our collection capabilities simply don't scale, and my argument would be, without getting into it at great length here, neither do our analytic approaches or our analytic organizations.

The calls went out after 9/11. They went out to the technological community, because it's quite an American thing to do. Let's get technology. Let's work this out. Let's fix this. Basically what that means is let's throw money at it. It's easier to throw money at technology than it is at people, because technology has going for it the one thing that people don't have going for them, metrics.

So it's easy to say, "I spent this money, and I got that result. I got more pictures, better pictures, better definition, better sound, better light, better—," you know, all better, better, better, better, better. The question is whether any of those better, better, better, betters were helping us with the one guy who's going to show up with a stupid bomb in his shoe. That's the threat that we're facing. That's not glorious, I admit, considering the great books that are written about World War II and the Cold War and so on and so forth, but that's the threat we're facing. We're not dealing with that one, not as organizations.

So the problem isn't technical. It's cultural, bureaucratic, conceptual, leadership, dare I say. Why is it important? Because I'm not arguing against technological improvements and contributions. I believe that those are going to happen anyway. I believe that they're happening too slowly in some respects. I believe that they're also misdirected in some respects, but I don't argue against them. I don't want to be placed in that position.

What I am saying, though, is that it's important that the flow of technological and scientific thinking, now more than ever, be undertaken with a full recognition of cultural, bureaucratic, legal, and social barriers that must be negotiated in coordination with those technological solutions. Not to do so risks the failure of even the best and most ambitious technological and scientific efforts.

Basically, you can invent it. They won't let you use it, and "they" is the people. "They" is the government. "They" are the media. "They" are even elements of your own bureaucracy. All of those things must be factored into the initial design stage of a new technology or a new technological approach, or else you're wasting your time. I cite you Admiral Poindexter.

The good news is we haven't been attacked again. The bad news is that we've slipped back into a sort of business-as-usual sort of complacency. Worse, we've seen the entire issue of intelligence support and warning become nothing more or less than a political football with the traditional and inevitable price for such a short-sighted and irresponsible approach to be paid by more of the innocents that we've sworn to protect and serve.

What can be done? The technological community must stop offering ad hoc individualistic responses to narrow inquiries and requirements. Just

because you can invent it doesn't mean it's a great idea. There's got to be a reason. There's got to be somebody that wants it and is going to use it and that you can sell on that issue. You have to do it in collaboration with them. We're not good at doing that.

It must sponsor, this technological community, integrated and whole architecture solutions that provide technological solutions and account for the kinds of bureaucratic and cultural issues that have hamstrung and hobbled many or most traditional approaches. Getting back to the scaling issue I discussed earlier, the evaluation of these new solutions must be measured by their ability to perform the mission, not to satisfy statistical norms.

Can this thing find a bin Laden, not the bin Laden, necessarily, a bin Laden, because when he's dead, if he's dead, there's going to be another one? It doesn't matter. It's got to be guys like that that we're after. Can it detect a bomb in a briefcase or a shipping container? Can it detect a nuke in a shipping container? These are the kinds of issues we have to deal with. Can it penetrate, technologically penetrate, a sophisticated security that rests not on impersonal bureaucratic procedure, but deeply personal, intense loyalties?

What do I mean by that? I mean, how did we break in to the Soviets and all the rest? We took advantage of the fact that they were as bureaucratic as we were and perhaps even slower. So we were able to monitor. It's the story of Enigma. You count the rotors. They forget one day to change the code. All of these things happen, and bang, a good mathematician and a good NSA and others will plunge right into that, but that's because it was impersonal. It was not being conducted on an intensely personal basis.

What's our problem with Al Qaeda? The problem with Al Qaeda is you can't just join up. It's hard. You have to be intensely loyal. These loyalties bring personal connections, and their security now is based not only on their access to high technology, but also their ability to protect that high technology with a degree of personal loyalty, that is at least the equivalent of an elite unit in the U.S. military or better.

It is indeed a priesthood, and that's a problem for us, because we're not good at breaking into things like that. What we're really good at is standing outside and watching what they do, but we can't afford to wait and see what these guys are going to do. We've got to be inside and be there when they start talking about it.

The government needs to make this happen, and serious legal reform is probably required. In the rush to improve competitiveness and protect against collusion, procurement reforms and other regulations have reduced the incentive for big business to play in important arenas, because basically they're doomed to failure in terms of achievement of the contract. That isn't some argu-

ment for big business. I'm not speaking for Microsoft, and for those of you that know me, you know I couldn't possibly.

I'm talking about the fact that we have to create circumstances and situations in which we take the very best we've got and apply them to the solutions to a problem, and we're not necessarily doing that. The government needs to acknowledge the help it gets. Very often, companies that provide discrete and sensitive support to the government are simultaneously vilified and pilloried. It's like a game of bad cop-bad cop.

And finally, and this is very important, because we talk about it in other contexts: the government needs to recognize the reality of globalized corporations. These people that we need to somehow get to work with us, to come up in conjunction with us in the Intelligence Community to develop these solutions, these people are no longer simply U.S. based or UK based or whatever.

They have an inability to publicly favor one government over the other in too obvious a fashion. They would risk serious financial penalties, not to mention, given Sarbanes Oxley and things like that, actual legal penalties from their own stockholders, were they to make a decision along those lines. We need to take that into consideration. Exemptions have got to be written into laws. And so these corporations are facing a situation in which they would like to help but cannot because of the law that we wrote.

These things have to be examined, and they're every bit as important as technology, because the corporations own that technology. You want to bring it to bear? You've got to bring them in. If you want to bring them in, you've got to make them convinced that they're not going to go to jail for having done it.

Laughable as it may be coming from me, I think that we need more revolutionary approaches, not evolutionary ones. I read a book by Billy Mitchell. My hobby is aviation and airplanes, and I do volunteer work at the Air and Space Museum. It's in my bio, and it's fun for me.

This guy was the great visionary of air power for the United States and elsewhere. On the whole concept of strategic bombardment along with Douhet and others, Billy Mitchell was way ahead of the pack. You even get a great movie with Gary Cooper and the court martial of Billy Mitchell. But, and this is really kind of neat, I think, in the midst of all this supertechnology. Billy Mitchell in his book has a chapter on commercial aviation, so here's this book that talks about strategic bombardment and precursors to B-17s and B-29s, and pursuit airplanes, and high speed and interception, and so on and so forth. And he starts talking about commercial aviation, and he says, "Well, there's a lot of problems with commercial aviation." This was back in the early thirties, late twenties. People are dying all over the place. Why are they dying? Because when the airplane comes down in these farmers' fields and whatnot, they keep hitting fences or low ditches in the ground and turning over. So Billy Mitchell's

proposal, in the same book as strategic bombardment and all that, his proposal for commercial aviation was that all commercial airplanes should have six-foot high donut low-pressure tires so that when, not if, but when they come down in the farmer's field, they can roll over the fences and roll through the gullies without turning over and killing the people inside. It never dawned on him for a minute that the answer was engines that don't stop. Don't come down in a farmer's field.

Last night I came back from Vienna, not the one in Virginia, but the other one, in a two-engine airplane. We're playing a game of statistical craps, right? You know what they call it? EROPS, extended range operations, or engines running or passengers swimming, EROPS. A guy in the thirties or forties would no more have taken a load of passengers over the ocean in a twin engine airplane than he would have stuck a gun to his head. Why? Because those engines weren't going to work reliably enough. What we've got now is we've got the engines that work reliably enough. That never dawned on a guy like Mitchell. So you can be a visionary sometimes, and you can miss on other parts. It all has to do with the breadth and the scope of your approach.

The technologies that are provided us are the most significant advantages, but all of those that provided us with those advantages in World War II and later in the Cold War were revolutionary. They were based on evolutions of existing requirements, to intercept communications, to read encrypted communications, to go faster, to deliver more and more massive fire power. But the solutions were novel and presented leaps in science and technology. Jets, computers, nuclear weapons, these were leaps, not unheard of, but they were leaps. Later we moved into space and established a monopoly again that stood us in good stead for decades. More of that is needed now, but can we do it?

Important parts of the deck are stacked against us because of the way we've set ourselves up, and this is nothing to do with technology. Could we even accomplish the Manhattan Project in 2006 when you consider the fact that 95 percent of the scientists who worked on the Manhattan Project would be denied clearances? It's true. They would not be allowed in the state of New Mexico or Arizona, let alone onto the Manhattan Project, because they were born someplace else. We've done that to ourselves.

Could we launch Corona? I went to a tech conference back when I was at the CIA, and it was really kind of fun, which featured the initial director of the Corona program. Corona was the first satellite imaging system. And what he said, and it was really interesting to me, he said, "You know, we went through this. We had all kinds of problems along the way. We were trying to invent this, and we were trying to invent that, and we had to find solutions." He said, "But the God's honest truth," and it's pretty much a quote,

"was that when I put my finger down and pressed that button to launch, I had no idea what was going to happen."

Now ask yourselves this. In the current environment, could we even get to the point of having that button there if there was a program where we didn't know what was going to happen when we pressed it? It would have been wiped out at some review years before it ever got to the point of that button being pressed.

We're cutting ourselves off. We've set ourselves up not even to be able to apply the kinds of technologies that we might otherwise be able to do. I don't have the answers to all of this, but I think that the answers are in the direction of these legal and social and cultural kinds of reforms that are required through all of our systems.

The problems don't stop there. We go back to the salad days of the Soviet Union. The U.S. created the most aggressively intrusive technical penetration capabilities known to man at that date. Go all the way to the seventies and eighties. But most importantly, consider this. The U.S. was able to field those capabilities, to utilize those capabilities with little or no legal oversight or moral concern whatsoever.

They were clearly and unambiguously pointed at the bad guys. We had our tootsies in the water, facing out, and we're beaming out that way, and we never really thought about beaming this way, and when anybody turned around, like I said, slap.

Can we say that now? Collection and analytic techniques that we've used for decades are being—that is the old ones, not new ones that you can come up with, the old ones, the ones that we used against the Soviets and everybody else, they're being seen in a decidedly more sinister fashion now that their use is directed internally or there is threatened use internally or implied use internally, and the targets are seen now more as individuals and less as faceless nodes. And once those faceless nodes turn into individuals, guess what individuals carry with them? Constitutional protections. These are not trivial matters. They're very important and significant matters that hamstring our ability to apply technology.

Real concerns arise over the conflict between improved technological solutions that are seen as encroachments to legitimate constitutional liberties. I am not a civil libertarian. I'm an intelligence officer. I spent my life looking under other people's covers. I was an ops officer, too, for a while. It was kind of fun. You look at the results, or you'd lift the cover yourself.

The moral dilemmas of the Manhattan Project people, for example, resulted in a huge literature but were largely internalized and personalized at the time. You didn't read about the problems that they were having out in the

desert. You didn't read about their moral apprehensions, not at that time. That all came later.

They weren't played out as they would be and are now, on the front page of every newspaper, every night on the evening news, or in front of an array of congressional inquiries. This is not an argument for a black field. This is not an argument for censorship. It's simply an understanding that things have changed. We can't do what we used to do.

We can't even apply the tools we already have, let alone tools that we might be able to invent, unless we prepare the society to accept the significance of it and implement the kinds of appropriate—appropriate—safeguards that keep them safe. They do have constitutional liberties. The only way bin Laden can win is if we screw ourselves. This makes a difference to technology, because even now a good idea requires careful preparation in terms of this public perception and acceptance.

So I'd say that science and technology, riding along the path defined by the changing nature of the threats, are rushing headlong into the arena of public debate, requiring perhaps an unprecedented degree of social as well as technical engineering to succeed. Corporate America is a strategic asset, no less than it was in World War II.

The currency of victory in World War II was steel ingots, and the United States had the ability to manipulate, control, and produce steel ingots and those things that result from steel ingots better than anybody else on the face of the earth, and that's how we did it. This is nothing to take away from the heroism of soldiers and good planning by generals and so on and so forth. It has everything to do with stark reality of massive war.

The currency of victory in the 21st Century, I'd argue to you up to a certain point, are digital ingots. The United States is in a position analogous to the one it was in in World War II in its ability to control and manipulate steel ingots, to control, manipulate, and affect the useful application of digital ingots in the new world war. We're not doing it. We need to. We have to find a way of making that happen.

Initiative and principal funding used to lie with government. It's not true anymore. The government doesn't have the funds. Within the government does not reside the technological expertise that it once had.

I don't want to pick a fight with the NRO. I don't want to pick a fight with anybody here in an S&T organization. The issue is simply macro. Where we were in the fifties and sixties and seventies were huge amounts of government money being thrown out, which the corporations went after.

It's the reverse now. The corporations have got the technological initiative. The government doesn't have the money. They've got to find a way to make that work. The initiative is largely with the private sector, in many

important respects, so it makes the responsibility for improvement and change more spread out over both the government and the corporations.

The bottom line—last page—is that we can devise information sharing architectures, knowledge management and search tools and almost science fiction-like dissemination architectures, but in the absence of the kind of bureaucratic and cultural upgrades that we've yet to see seriously proposed, let alone adopted, none of these are going to have the desired effect.

QUESTIONS FROM THE AUDIENCE:

AUDIENCE: I have a question about governance in the Intelligence Community. NASA dug itself out of the hole that it was in by improving governance. It re-established the boundaries between client, project manager, and engineer. Once you get the balance right, the governance right, everything else flows. Corporate governance is the same thing. What about governance in the Intelligence Community?

MR. PAPPAS: What governance inside the Intelligence Community?

AUDIENCE: Has anyone attempted to identify the primary roles and responsibilities?

MR. PAPPAS: Well, yes. DCI has his, the Director of DIA has his. The Director NGA has his. NRO, DNA, everybody's cut their own piece out. I don't call that governance.

I'm a Yankee. A guy I work with is from Alabama. He believes in confederacies. I don't. I believe in federalism and what the Intelligence Community resembles more than anything else is a confederacy. The stove pipes are real.

They continue to exist. I haven't seen anybody make a successful attack against a stove pipe to date. Have you?

So with that in mind, it's very difficult to deal with governance of the IC, and that's an issue for the DNI to deal with. The DNI, in my opinion, has had lots of arguments with people. The DNI, in my opinion, is a great idea. The idea of the DNI and the fact that something like that was proposed is very important.

That the DNI does not have the kind of financial and personnel authority required to cause other elements of the community to queue to the DNI means that it does not have actual—in my opinion, personal opinion only—does not have adequate governance, to use your term.

My business partner Jim Simon and I wrote an article just before we left government that was published in *Studies in Intelligence*, in the unclassified one, having to do with the future of the Intelligence Community. Each of the stove pipes has its own great ideas for where it wants to be in ten years, and so it applies its money, its manpower, its intellectual resources to going to that point. If that point for the NRO is different than that point for DIA, and it's different from that point for INR, and it's different from that point for the FBI, and it's different from that point for the DHS, then I fail to see the utility of having all of those approaches, unless they can be somehow coordinated and the technology is made compatible. We don't do that very often. We don't do it very well.

The military is engaged. There's a war going on between the Intelligence Community and the military over who's governing what and who supports the war fighter and who doesn't, and how do you support the war fighter, and how many assets do you apply. These are all issues that are old issues. They're not new issues. They're just being played out on this field now, because it's an opportunity, but I don't see any new thinking there.

AUDIENCE: I wonder if you'd talk a little bit about sharing intelligence with the corporate sector. Does the Intelligence Community have any responsibility to provide information back and/or to the press? Witness today the *Wall Street Journal* editorial.

MR. PAPPAS: Oh, God, witness what I didn't read, always bad.

AUDIENCE: It said that it declassified the NIE on Iraq, since it's being leaked selectively and discussed it as an integral whole.

MR. PAPPAS: They didn't say so in this thing here, but I was a member of the Kirk Commission that did the first and, I think, arguably, still the best review of our work, the Intelligence Community's work in Iraq. I mean, we saw what they did wrong, we saw what they did right, and we said so, and it's held up for several years now.

Declassifying the estimate is not going to help anything. That's just going to contribute to the political fire, and so they'll sell more papers and more digits will be burned, expended, or whatever the proper term would be.

But you asked a question about sharing information with corporate America and elsewhere. I think an important reform that's required, and this is one that's underway, but for those of you that are aware of it, you'll also appreciate and recognize it's underway at a glacially slow pace, and that is the reform of classified to open source as the basis.

When we had a focused target like the Soviet Union, it was appropriate, in my opinion, for the classified and technical to lead and target the open, because the open was so broad and unlikely to provide real insights, because, after all, how much could you get out of a controlled newspaper coming out of Moscow? It's not going to tell you about the bore diameter of a T-72 tank. It's not going to tell you about missile capabilities and so on and so forth.

So we developed a culture in which the classified was preeminent and had every reason to be. I think if we take a good look at what we're facing now, we have to reverse the situation so that open source information is, in fact, the targeting format and that open source is used to target classified, rather than vice versa. And that gets into the corporate structure, too.

I've had this argument, and I don't want to get into broad philosophy, but the CIA and the whole intelligence establishment of the United States is abhorrent in the history of intelligence, because it was so focused, because it had a single opponent, and because it was conducted along these Kabuki-like lines that I just outlined and that you know even more about, each of you in your own way.

The traditional history of intelligence is through the use of diplomats and businessmen, and I mean traditional meaning depending on which book you read, intelligence is either the first or second oldest profession in the world, and there's a reason they've both been around for as long as they have.

Those were not conducted by military officers. Those were not conducted by armies of analysts and collectors and highly specialized MOS types and so on and so forth. Those were collected by people who had the opportunity to observe the foreign culture and had sufficient interest to be able to report back on what they saw.

So what we did during the Cold War was invent a whole new art form, which is not necessarily serving us in great form right now, witness our inability to fundamentally understand the kinds of problems that are occurring in the Middle East. And I'm speaking as an intelligence officer, not a political statement, okay. Please, please bear with me on that.

We need to penetrate these societies with a degree of understanding that's not going to come out of simply creating a branch with a GS-15, two GS-

13s, and a secretary. That's not going to happen that way. It's going to come from dealing with the people who already have a basis of knowledge, which means opening ourselves up to communications not just with corporate America, but you left one out, and that's academe.

Academe has serious, serious things that they can help us with and should help us with, and yet we're not willing in some respects, and I'm being a grinch now. You can find an exception to this, but we're almost willing to let that happen. They don't want to talk to us, and we don't want to talk to them. No, we need to talk to them, because they're there, and we're not.

AUDIENCE: Along those lines, many academics couldn't get a security clearance.

MR. PAPPAS: Yes, that's what I said.

AUDIENCE: Your Manhattan Project example is just perfect. A lot of the guys that could hack into a North Korean computer are people who perhaps have greasy hair, eat Fritos all day, might wear sandals to work, might do a little dope on the weekends.

MR. PAPPAS: No Microsoft talk, now.

AUDIENCE: And God help you if you're a 22-year-old Farsi speaker who came over when she was eight years old and still has 72 relatives back in Tehran. She's totally on board with our culture and our agenda, but forget it.

I just have this fantastically troublesome feeling that there's this enormous brain trust out there equal in size, perhaps twice the size of the Intelligence Community, but it's being sacrificed on the altar of our security procedure.

MR. PAPPAS: Absolutely. Absolutely.

AUDIENCE: Is there a way to establish institutions on the periphery of our community to utilize these people?

MR. PAPPAS: No. You had me right to the end. Anything you put on the periphery will stay on the periphery, because it'll never develop the kind of momentum that's required to charge in toward the center. There's some sort of a physics analogy there, I'm sure, that I'm trying to make, but it'll never make it, because it'll be held out by the existing structure.

I truly believe I've had enough of evolution. I've had enough of the promises that we're going to work on something. We'll develop a little thing. It'll grow by itself. Baloney! Nothing grows by itself. It has to be force fed.

And so I think that you're absolutely right about squandering resources. Listen, what's the greatest shortfall that the military and the Intelligence Community has? Linguists. This is the United States of America. We have better Lebanese than the Lebanese have. I mean, that's not my joke. That's an old joke, right? Why did we do so well? Because we kept the Germans.

But this is a serious issue. We have a Moslem community in the United States that is different than the Moslem communities in any of the European

states in that it has been assimilated. And are we using that community? No, not in my opinion, and so I completely agree with you, but I don't believe that setting up a peripheral organization is going to do it. I believe somebody's got to get a two-by-four right across the top and say, "Make this happen."

I'll give you another example. I went to a conference. Army officers in the room. Army IT is fragmented. Why? Because each one of the individual war fighters has to have his own responsibility.

I was a CIA officer. My job as a CIA officer was to fight with DIA on a daily basis. It was a legitimate fight, because they had their approach, and we had ours—we had our mission. They had their mission. There was a reason for that mission occurring, and there was a reason for the fight.

But when I saw what happened to DIA, as it was effectively Balkanized into the support of the war fighters, I thought an enormously important asset was being squandered so that we could get 32 different editions of a morning report or a daily report instead of one good one. Personal opinion, of course.

AUDIENCE: You said that today's threat is different. It's man-to-man, suitcase-to-suitcase, can't be solved by technology because technology has metrics, but people don't. I think there are two problems basically. One is how the intelligence analysts share information and the other is the conceptual construct of how our enemies operate or how do they think. General Poindexter floated a revolutionary idea, and he was shot down. Revolutionary ideas let the intelligence analyst bet on wars. I think it's a fantastic idea, because they are involved. The future is involved with this, but our society or our culture did not accept that, and it was shot down, and we're talking about breaking the social barriers, bureaucratic, culture, and so on.

The problem on one side is the intelligence analysts, and the other side is to understand how Al Qaeda or the Moslem resurgent movements, and there are—it is more than Al Qaeda—operate in synch, and if we want to change them, we have to come up with a possibly revolutionary idea, implant a virus for example, and find out whether a virus that is implanted can change this enemy that we have.

We can destroy the Soviet Union, and nothing will be left except Marx and anger and some writings, but if we destroy Muslim countries, what is left is the Koran, and it's very difficult to get rid of that. Your comments.

MR. PAPPAS: I think I agree with you. What I'm trying to say is that as a manager of analysts, I became distressed over the application of technology, which allowed it to become increasingly easy for an analyst to pass off quantity as quality.

And so, you know, it's that "find the needle in the hay stack." That's assuming there's a needle in the haystack. You can look through as many haystacks as you want, and most of them are not going to have needles in them at

all, so you can waste your life coming up with statistical examples of how to go through searching needles in haystacks, but I would prefer to find out where there are really needles, and then go look there.

But the point that I think that you make with which I resonate the most is the fact that we're up against a problem now of understanding, and it's a problem of understanding that has to be fed into policy concerns, which are not our concern, but we don't necessarily have the wherewithal to affect that understanding because of where we come from and because of the way we've been set up, and we really need to do that. We need to hire the people that he (Poindexter) was talking about. We need to generate a situation in which their skills and capabilities can be applied, even if they're not useful on a day-to-day basis. These are long-term issues, and we're not very good at them, and we don't have the patience for long-term issues, because long-term issues, and that's where I'm going to get back into the metrics business.

You can't show a quarterly return on investment, and so on and so forth. You don't get quarterly returns on investment with good intelligence. You get penetration, and that may not pay off for a decade, but it's going to pay off well when it does. I think that's what you're trying to say.

AUDIENCE: I have one question for you. When we talk about being more open in terms of both decreasing the stove pipe, in which I agree with you, but also being more open to people who are unclearable for a variety of reasons, how do you deal with the likelihood of efforts at deception?

MR. PAPPAS: Oh, I think that deception occurs. I think any intelligence officer, whether he's a collector, analyst or whatever, that doesn't consider the fact that deception is in his environment is just missing the point. So I don't worry that much about deception. I don't worry that much about it, because I assume it's there. I assume deception.

I assume deception, and the way to deal with deception is through two devices, one of which is serendipitous, and the other one is statistical. The serendipitous one is you get a penetration that tells you you've been deceived, and that's rare, but it happens. It's a good thing to go for.

And the other one is statistical, and that is everything is telling me this is wrong, so this has to be. It cannot be. It doesn't sustain itself in the flow of information, and if you open yourself up to a free flow of information with more open source, it's much more difficult to deceive, isn't it, because there are so many players in this game.

I used to go—in CIA they'd send me down to talk to this thing called the Presidential School Room, and it was groups of young students that came to Washington, and they go to different government agencies, and it was fun for them. It was kind of fun for us too.

Every single time I went, the question I got from the kids was, "Who killed Kennedy?" You know, CIA guy, right. "Who killed Kennedy?" Or, you know, stuff like that, and I'll give you the answer, because it pertains to this. I'd ask these kids, "How many students in your home room?" "Oh, ten, 15," you know. "You think you could construct a conspiracy, you know, of only three or four people within just that 15, let alone the whole school?" and they'd just realize in a heartbeat you can't. You can't do it. It's too tough.

The more open the information, the more difficult it is to plant a seed of deception, because you can't control this flood that's coming in. If that's what you want to waste your time trying to do, then that's great. Good luck. You lose, you know. We win.

So I think that the more open it is, the greater the flood of information. The greater the access to all sources of information, the less effective a concerted deception campaign will be, because it'll get lost in that threat. I'd have to think about that more before I made a mortgage bet out of it, but that's my first answer.

AUDIENCE: Let me pose another issue. One problem, I think, that's fundamental is that there's a huge amount, even today, of information coming in at the bottom. It is distilled and distilled and distilled as it goes up until it may be one sentence after the president's daily brief, and if he's curious, maybe a question.

So what we have are the people who must make the decisions operating on a very small fraction, and not a random sample but often a skewed sample of information, and they may indeed get more that affects them cognitively from reading the newspaper or talking to reporters than they get from the Intelligence Community after this distilling process is complete. How do we deal with that, and what role does technology have to play in making for more effective distillation?

MR. PAPPAS: Stop competing with newspapers. Why should we produce things that look like what the newspapers can produce? If the newspapers are producing it, and it's within reasonable range of being correct, by which I say 75 percent. , then there's no need to compete.

I've never read a single thing about which I was personally acquainted that was more than 85 percent right, but, I mean, that's because we never told them the truth. And three quarters of the time, by the way, we could have told them the damn truth.

Reporters, in my opinion, are an asset, just like foreign language speakers, and so on and so forth. We've defined ourselves into a whole list of enemies that we don't have to have. Now this is not to say that there aren't malicious reporters out there, but let me assure you, there are equally malicious government people who try and screw the press.

I went to a conference a few years ago that we helped set up in Philadelphia on homeland security, and I thought it would be a great idea to have a symposium in which the press and the DHS—it wasn't DHS, but, you know, government types—would sit and talk about one of the greatest warning assets that the United States has got, and that's the media.

I mean, we can spread information quickly compared to some other places. And most of the people that I spoke to in the media were perfectly willing to deal with a situation like that, given their constraints, and so on and so forth. It's a negotiation.

So we had this symposium. It was really amazing. It was absolutely amazing. It was sort of sad, but you sat back and took it in. The first speaker got up. It was a member of the press, and he started with, "Well, we only reflect reality. We don't actually make it, and besides, we're always being deceived by the government, who is planting false statements, so it's incumbent upon us to serve as servants of the people and tell them the truth." Whereupon the government guy stood up and said—unprintable.

Okay, and then they started flying, and in the ensuing question and answer period, the word "tyranny," "tyrant," and "dictatorship" was used about 15 times, back and forth. So, okay, those two aren't going to play well, but we're not set up to play well, and there's no reason why we shouldn't be.

There will be problems when you do something like that, but kind of like the same thing in my answer to the previous question, I think that little glitches get lost when you increase the volume of the flow. So if you actually do develop an approach toward the media that uses the media, not in some bad way—see, as soon as you say, "Use the media," the reporter up there says, "Well, they're not going to use me." But no, not that way – but one that uses the authorities and access and the fundamental approach that the media has and their penetration of the American society to help us explain things.

You talked about Admiral Poindexter. You know, the people who objected to Poindexter's program—about which I am not competent to speak, so I'm not trying to defend it or otherwise—didn't know one thing about what it really was. All they knew is what they read, and what they read was it's some sort of a betting thing.

Well, as soon as it was defined in those terms, I'd have put 100 bucks down, "This is going to die." And they would have taken my money, too, and I would have made a few bucks on it, but it wouldn't have been high odds, because it was going to die as soon as they associated it with something like betting. It was simply a matter of perception. We didn't do that. That's our fault, we professionals here. My opinion again.

AUDIENCE: The question I have kind of goes back to when you were speaking of students from foreign countries. Right now they're actually

saying that in foreign countries, because I'm a recent graduate myself, that in foreign countries such as India and Asian countries, most of their curriculums are actually designed for the production of engineers, scientists, and technologists, and that basically the way that America's going right now, we're looking at an upcoming shortage in the amount of engineers and technologists that we currently have here within the States.

So do you believe that the American education system should change its overall focus to an S&T-based curriculum, or what would be an effective short-term solution, because as we enter into clearances—it actually took me a year to get my clearance. I'm 22 years old, an American citizen, have only lived in one place. In my case, I did not actually have to go into that thickened bureaucracy that you've been talking about, so what's an effective short-term solution?

MR. PAPPAS: You're not going to like my answer. We have enough scientists. We have enough engineers. We have enough people that can add. We don't have enough people that can read and write.

We reacted to Sputnik in 1957 by fundamentally changing our educational structure and all the issues revolving around that, and it was the right thing to do, because we had a surplus of people that could read and write. We didn't have enough people that could add, and I'm using add, you know, to cover the technological.

I think that situation is now reversed. I do not believe the arguments that say that we are necessarily behind either the Chinese or any other nation on the face of the earth, because those people are training themselves so that they can come here and utilize their skills. And to a certain degree, in a globalized economy, we're going to use their skills in place, so I don't want that to sound like a nationalistic issue.

My wife's a teacher. I think if you talk to an educator, you're going to find that we've got a surfeit of people that can deal with the technological issues that support things like Microsoft or IBM or Hewlett Packard or who knows what, but we don't have people that can read and write anymore. My wife is a science teacher in Fairfax County and she has to spend a certain portion of her day in the science classroom doing reading, which people couldn't do. They can't express a thought.

If we can't express a thought, if we can't read, if we can't write, if we can't understand the importance of cultural issues as opposed to simple technological ones, then we will never answer this gentleman's question here about how do you truly understand Al Qaeda and the Moslem world. That is not a mathematical equation.

So I don't mean to be rude. It's just that I think that the answer is I don't agree with your premise.

National Consortium for MASINT Research

Joseph Swistak
Aerospace Corporation
The National Consortium for MASINT Research

I'M GOING TO CHANGE gears here a little bit on you. I've heard a couple of great talks. What I'm going to do is give you an example of one of the things that we're doing to try to address some of the problems that I think have been raised here this morning. I'm going to talk to you about the National Consortium for MASINT Research, NCMR, as we've abbreviated it.

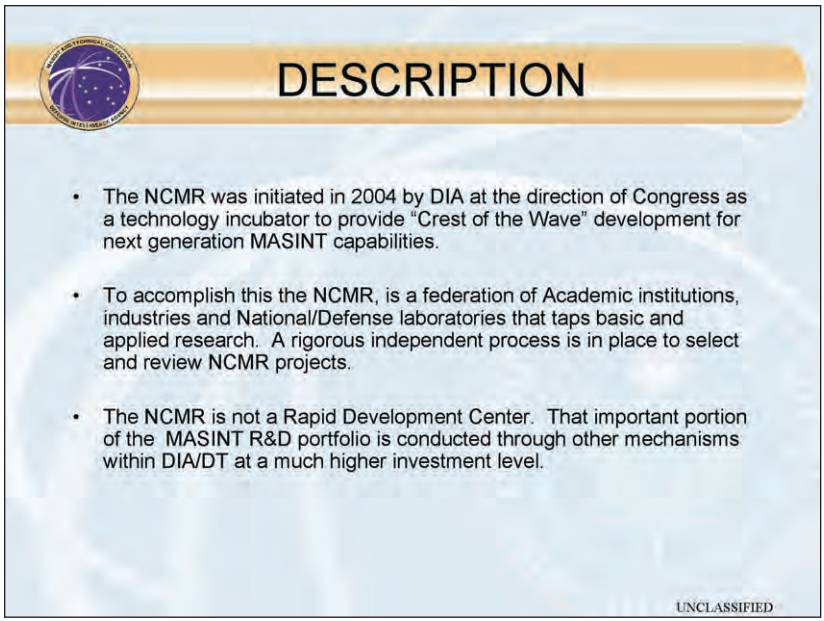

Figure 74. Description of NCMR. *Source: Author.*

I am going to talk to you about what the Consortium is, how it came to be, how we operate, and how we do business, and then conclude by giving you a couple of examples of some of the activities that we're engaged with.

It was actually initiated under direction of Congress addressing the technology issues saying we're not investing enough in some of the basic research activities that are going to give us longer term solutions to some of the problems that we're seeing. So they directed us to start in 2004, the crest of the wave to get the next generation started, if you will.

The Consortium is a collection, not a federation, of universities, national laboratories, government laboratories, private industry folks coming together to solve some of the basic technological problems we have, focused in the MASINT community, the measurement and signatures intelligence part of the world. The thing that it is not, it's not a rapid development type of activity.

A lot of folks today believe you can go from statement of a requirement to a solution in six months, and that is not true. If you have capabilities in place, yes, you can do that, often, depending upon how the requirement is stated, but truly to take a new concept, a new idea, and evolve that into an operational capability is a long-term process.

I can use blue-ray technology. I mean, it's a laser technology, high frequency laser technology, started 40 years ago. And if you had asked the developers or the people who were engaged at that point in time what would be

the biggest user of laser technology, they would have not told you the gaming industry and DVD industry, because we were developing it as a weapon system. So that's part of the evolution.

Currently, the NCMR has 19 universities engaged and nine government laboratories. There are three university-affiliated laboratories, 12 industry partners, and then seven government organizations that are part of this consortium.

There's a core group. It's not exclusive to that group. If these members choose to bring in people who are not part of the core group into the activity, they're welcome do to that. Universities can be brought in. We're especially open to universities and university activities, just because it's—we believe that's where the new ideas are really going to come from.

How are we structured, and how do we do business? The university research, the way we've laid this out, we figure a university activity, once it's initiated, should go for at least a three-year period. It takes a while for an idea to basically gel and become kind of a working type activity. At the end of three years, it either gets transitioned into a partnership activity, or it gets terminated, or we let another government organization such as the NSF pick up the funding for that, if they are interested in it.

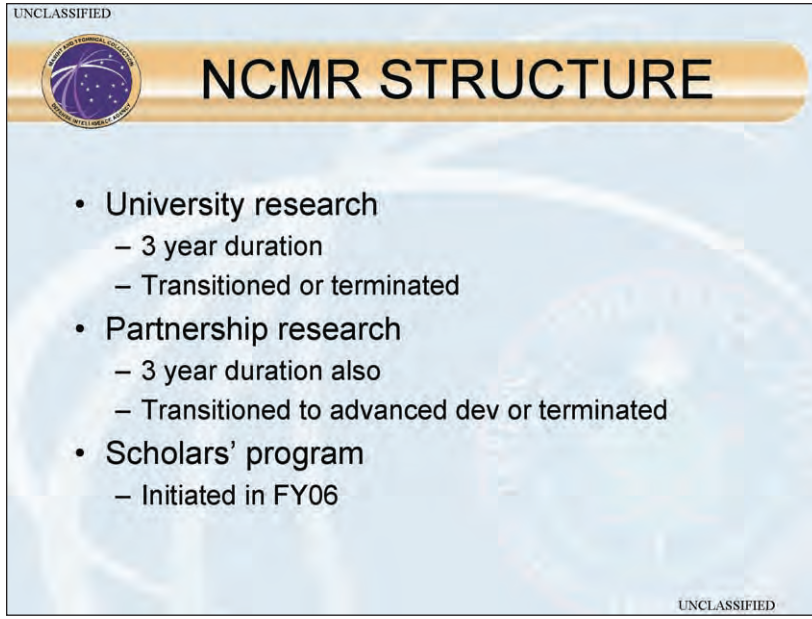

Figure 75. NCMR Structure. *Source: Author.*

The partnership activity is also about a three-year type of activity. That's where you bring in the industry partners. They're the folks who can take the concept, begin to put it into some sort of a prototype capability where you have an operational thought or idea as to how it's going to be applied brought into it. And then at the end of that three-year period of time, that is when the program or the activity would be handed off to our advanced development folks for then full-up development.

Part of the program that we've initiated this year is a scholars program. You've heard it said that we've got enough scientists and engineers. The Intelligence Community, the DNI and others have said, "Now we really need to concentrate on that," So what we have done, and I'll talk more about this, is initiated a scholars program where we're now working at the undergraduate level.

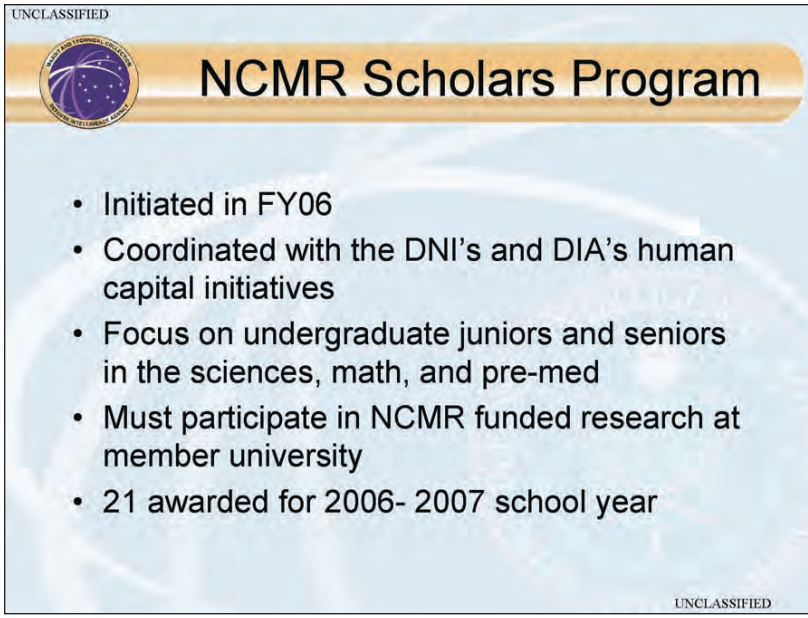

Figure 76. NCMR Scholars Program. *Source: Author.*

And we're coordinating this with the DNI and the DIA's Human Capital Investment Program, so it's concerted—we're not off running independently on this activity. As I said, we're focusing on undergraduates and trying to capture them when they're young.

We are hoping these scholars will come into the Intelligence Community. We want to give them the opportunity to work in an unclassified

environment on ideas and let them know that they can do work for the Intelligence Community. If they can continue to do good work and do good research, and we're looking for individuals who are in the sciences, math, pre-med type of activities.

One of the requirements is that if they are a scholar, if they get an award, they will participate, because the universities that are part of this are the ones who have recommended the students to this program. They must participate in the research at the university. They're actually invited to attend the program reviews. And we actually awarded 21 scholarships this year to different students, with different amounts depending upon their qualifications.

Sometime during the summer, and I don't have specific dates on this, because they're not firm from year to year, but we make an announcement of which topics are of interest that we're focusing our activities on for a particular year.

Figure 77. Program Selection/Retention Process. *Source: Author.*

We have a call for white papers. These are three- to five-page concept papers that people can put together. We have a panel of subject matter experts that will review these and make selections. A call goes out for proposals based upon those white papers. Sometime in the winter, normally in the December time frame, there will be a selection of proposals. The awards generally occur in the spring.

All our university activities are handled as grants through the NSF, so that's a fairly straightforward process. And then semi-annually we have a review of all the activities that are ongoing at the various universities in the partnership components. So it's a fairly robust system, fairly well defined.

Let me give you a couple of examples of the types of things that we're investing in. MEMS (micro-electro-mechanical system)-based miniature microphone for directional sound sensing. This is work that's actually being done at the Naval post-graduate school by one of the students out there.

The idea was to develop a miniature sound sensor directional capability based upon the Ormia ochracea fly's ear. The fly doesn't hear sound and doesn't orient direction of sound based upon the classic way that we think of it in terms of how the humans treat sound, in terms of time of arrival and amplitude of sound at each ear.

The structure is such that their ears have a couple of hinged rods that flex based upon sound amplitude and phase, and it's the combination of those two properties that help it basically determine where sound is coming from. And they've developed a MEMS structure that duplicates that, and the simulations that they have actually conducted of that hardware have said that it will operate in a very similar manner to how the fly's ears do. The intent here of that is we have current acoustic arrays that tend to be fairly

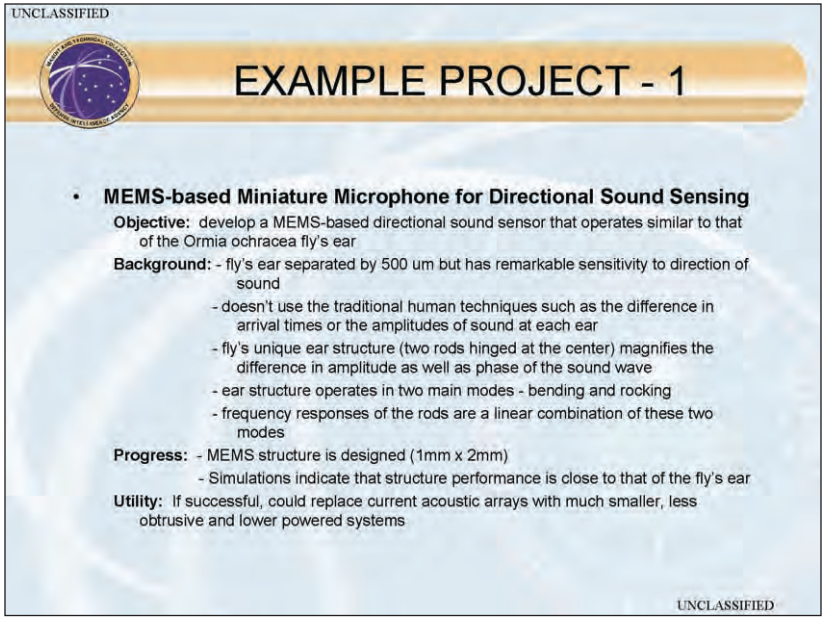

Figure 78. Example Project — MEMS Based Miniature Microphone. *Source: Author.*

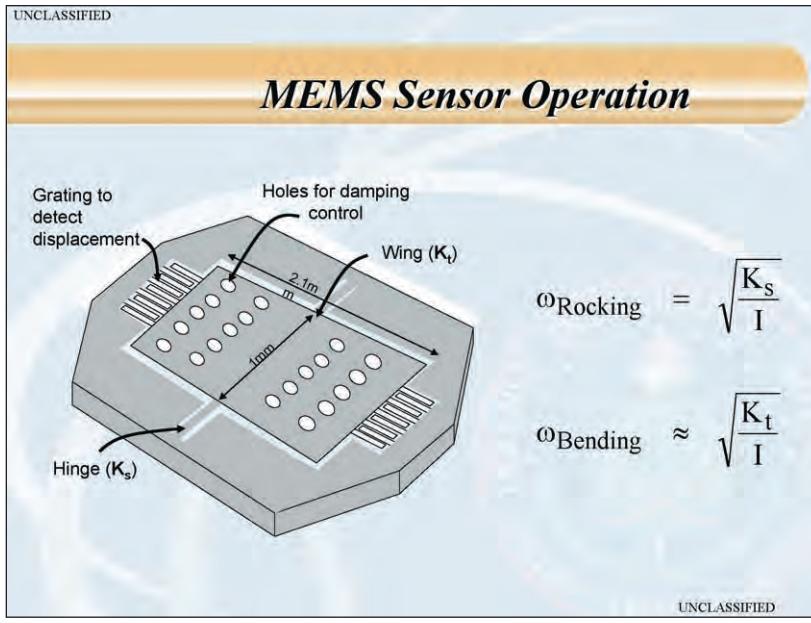

Figure 79. MEMS Sensor Operation. *Source: Author.*

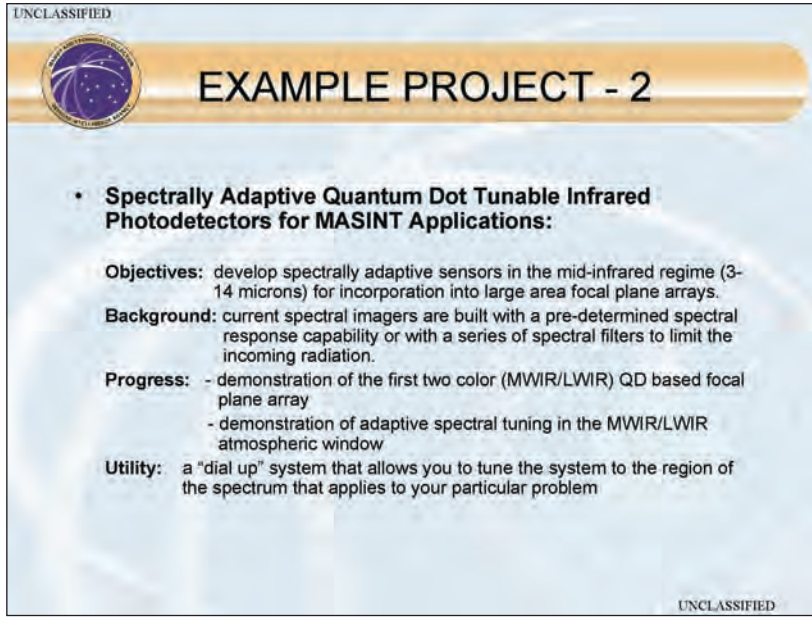

Figure 80. Example Project – Spectrally Adaptive Quantum Dot Tunable Infrared Photodetectors. *Source: Author.*

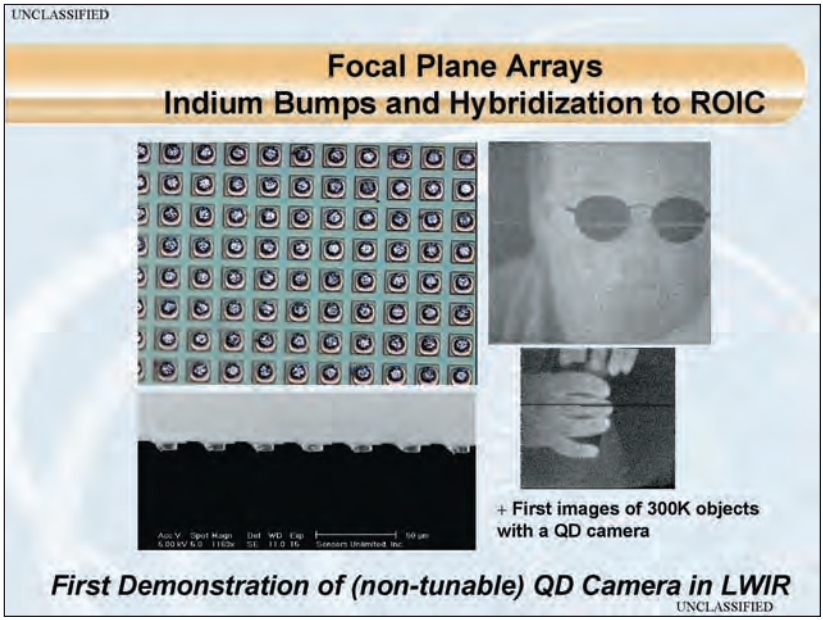

Figure 81. Focal Plane Arrays – Indium Bumps and Hybridization to ROIC. *Source: Author.*

large. You have to have distance separation between your sensing devices and the processor to be able to get the direction. If you combine that system into something of this size, you've now basically increased the capability in terms of reducing the amount of power, portability, and potentially level of accuracy. All that is to be determined.

Now once again, this is a university-based activity. It's in its third year. Results so far have looked good. We're hoping that it's going to be one of the ones that goes into a partnership type of activity.

Another activity is especially active, "quantum dot tunable infrared photo detectors for MASINT applications." If you're familiar with IR systems and hyperspectral systems, you know that generally systems tend to operate in some sort of a broad based eight-to-14, three-to-five micron type of range. If you want to then become more spectrally focused, you use some sort of front-end system, either a grating, a prism, filters, or whatever, to focus the incoming radiation in some region of the spectrum.

Ideally, back when I got into this business, into hyperspectral technology a dozen-plus years ago, my thought was if you could have a system that you could tune the frequency that you were interested in operating in and also adjust the bandwidth of the system, you'd have an ideal sensor, because you could have built a sensor that would work for a number of different applications.

Figure 82. NCMR Future Projects. *Source: Author.*

We're getting there using quantum dot technology, because now what you have is a focal point array that you could begin to adjust the frequency on, similar to the way you adjust your radio. You're not happy with what's playing on one channel, you change the frequency, and you get something else. So that's basically another capability that we're looking at, as an example.

They actually have developed the array. They have it imaging. This is in the broadband region. They have not done the tuning. They've been able to tune, but not in an array type of capability, but we're getting close, so you've got one part here where you can actually begin to tune your array to the frequencies or the bands that you're interested in examining.

What's next? The consortium is sponsoring a workshop at Argonne Labs at the end of November of this year on barrier penetration technologies. We've got one program that we've been working on. It's a neutrino type of technology where you can actually penetrate metal and concrete walls and actually determine what is contained or what may reside behind them.

There's a number of different types of approaches that are being used, and what this workshop is going to try to do is we're bringing much of the user community together, as well as the people who are developing the different technologies. We're going to let the users talk about what their requirements are, what scenarios exist for which there are needs for this type of technology. We're then going to let the technologists work toward identifying which approaches

work best against which problem sets and focus technologies against problems and make things move forward a little bit faster.

Our next business meeting for the NCMR will be in December. We also hold a couple of business meetings every year just to have the people who are invested in this take a step back, look at it, and learn whether we are making progress in the right direction. And then our next technical review is scheduled for the end of March at the Pacific Missile Test Range, tentatively. We're still working the details of that out. We just concluded one at Argonne again a couple of weeks ago where all the participants were there.

I should say this is a collaborative activity. One of the requirements that the Director, Dr. Bythro, has put on the participants in this is that when they come to these semi-annual reviews and make their presentations, they don't come strictly for their presentations and then leave. They have to be resident, there for the entire time that it's going on and listen to all the presentations.

The idea is the collaboration, because we're looking at people from a variety of disciplines. You've got people in different fields of physics. You've got engineers. You've got biologists. You've got chemists. You've got materials people. You've got a real broad spectrum of folks, and the idea is to get them together, to listen to each other, and start working collaboratively.

And we've seen several programs now where different universities have gotten together to work problem sets that are of interest. We've got some folks from industry who are approaching universities to take their ideas to the next step of capability, so the idea is to push the technology in a structured fashion.

Toward a Defense Technology Warning System

Stephen Thompson
Director, Defense Warning Office
Defense Intelligence Agency

GOOD MORNING. I WANT TO THANK Mr. Clift for the opportunity to come and speak to you this morning. I was taking quite a few notes, as I'm sure most of you are, about some of the presentations that preceded me, hearing a lot of very interesting ideas and thoughts, and I guess one of the things I was struck by was some of the common themes that keep arising, and I know folks are expecting some action from this conference, and hopefully some ideas that I'm going

to present this morning will at least help you think about some ways to maybe solve some of the problems we're facing.

I thought that the comments by Dr. Oettinger talking about how it's not so much having the knowledge that's necessarily what's going to make a difference in the future, but it's who can take that knowledge and apply it first to do something with it. And in the business that we do in the Defense Warning Office, that's very important, because if all you do is build a system that can collect copious amounts of information, and you can't actually do anything before an event takes place, then all you've really built is a superb forensic system and we don't want to be part of that. We want to do something better.

And then Dr. Colwell said that S&T can be used proactively hopefully to address or maybe even predict where infectious disease outbreaks might take place or where acts of potential bioterrorism might occur. That's sort of the direction that our office is trying to take, where we use S&T to predict where things might occur and take action before they occur.

There's a couple ways of looking at what S&T can do. I certainly agree that S&T is key to hitting the target, which I believe is a theme of this conference, and most of the speakers you're going to hear from today are going to talk predominantly about the collection issue, getting information that's needed.

I want to talk about the other side of the coin which is the analysis piece of it, and the S&T intelligence analysis is equally important. It needs to keep up with collection. As you hear more and more about new tools that are being developed, new capabilities to collect data, there has to be another side of it that's technically competent to look at that data and determine what it means.

In our office, we sometimes talk about taking data and evolving it all the way to wisdom, and we believe it kind of goes from data to information to knowledge and then, hopefully, whoever the decision-maker is, you impart wisdom to them, and they make the right decision in the right amount of time.

So what we're trying to do is build something that will help us keep pace with the collection folks that are building better and better S&T tools for us, and I hate to use the same metaphor again, but sort of try to find a way to find needles in haystacks that are getting bigger and bigger, because we're getting more and more data, and we're not getting more analysts, necessarily, to do that.

And we want to fulfill the mission that our office was given about four years ago, which was to give the earliest possible warning of technological developments throughout the world that might lead to technology surprise or somehow undermine our capabilities. So anyway, I hope that sort of gives you a setting for the remarks I'm going to make. This is the outline that I'll be following.

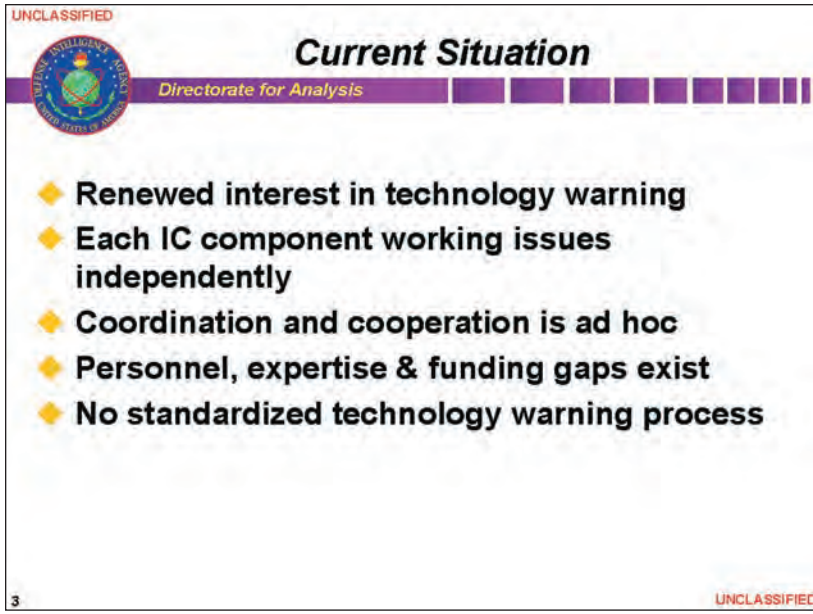

Figure 83. Defense Technology Warning System—Current Situation. *Source: Author.*

My assessment of the current situation may not be totally accurate, or you may disagree with some points, but I think, from what I can sense in the community right now among scientists and engineers who are on the analytic side in the Intelligence Community, that we're sort of on the verge of a renaissance in S&T.

We're getting more and more questions asked of us about S&T issues. We're being asked to give better answers, which is good. If folks demand it, then maybe we'll some day be able to meet their expectations, so we're encouraged by that, even though it's daunting to get some of the questions that have been given to us recently.

We're seeing that the community seems to be coming together. We've been somewhat fragmented, and I'm not sure exactly why that is. I'm a relative newcomer to the Intelligence Community myself. I spent my entire career in the Air Force acquisition world.

It seems that the interaction between the different service intelligence centers and the activities here have somehow gotten somewhat fragmented, and, of course, the staffs have gotten smaller. But now it's coming back together, and it's very encouraging, because the only way we can conquer a really hard problem is to work together, and I want to talk to you about of building some sort of a system that's holistic, that can do defense technology warning, and in a very collaborative, collegial way.

If we were going to build such a system, I think everyone hopefully would agree that those shown here are some of the attributes that we'd like to see, and the bottom one is the one I want to stress the most. We need to take a longer-term view, and that's hard when so many urgent issues are pressing on us today.

We're trying to build a concept like one from a few years ago—an oil filter commercial that said you could pay me now or pay me later. The idea is that sooner or later, a problem is going to come back to get you. And so we're asking folks to think about carving out a small amount of their assets, people and money, to start thinking about problems further down the road and not just waiting until they're here.

When we were first posed with this technology warning issue, we thought, "Hmm, we need to do something like that. Has anyone ever done it before?" Again, being a good scientist, there's no sense in repeating an experiment that's already been done and proven. And so we asked, "Who are some candidates to have done a global technology-based warning system that was predictive and issued good warnings?" We came up with the National Weather Service as an entity that has done a good job with that. So that's sort of the model I want to carry you through the rest of the briefing.

Figure 84. Defense Technology Warning System—Desired End State.
Source: Author.

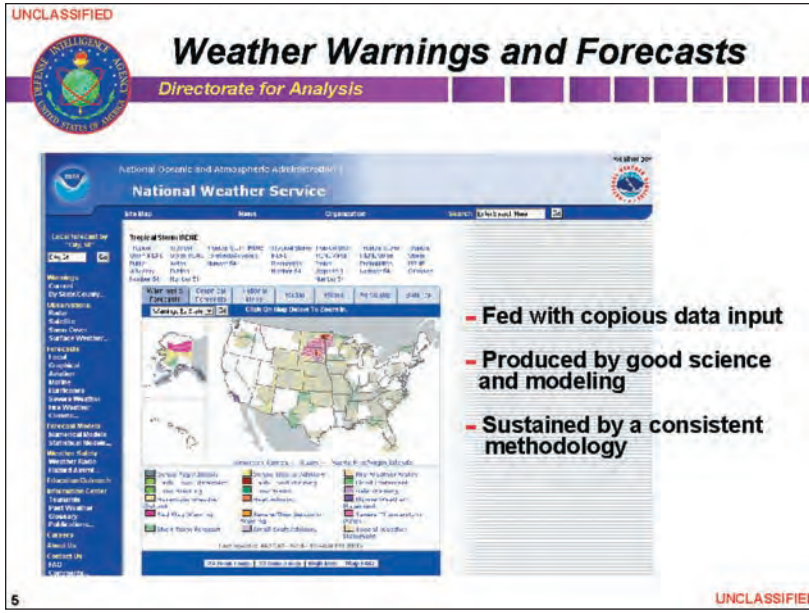

Figure 85. Weather Warnings and Forecasts. *Source: National Weather Service and Author.*

I received this chart from the National Weather Service's page, and I'm sure many of you have seen slides like this before. We were struck by some of the things that just jump right out if you, if you go to their website. One of them is the high information density that's portrayed on this one slide. Not only can you tell where bad weather's happening in the United States, you can tell where bad weather isn't happening. That's important. Most of the ways I've seen intelligence produced in the short amount of time I've been here, is that we do it in sort of a piecewise fashion, so I can give you data points on certain things, but I don't know if you didn't write a paper on a certain scientific issue because it wasn't happening or because you just haven't gotten around to it yet. Our new approach shouldn't permit that kind of problem in the future.

There's also a finite set of products that the National Weather Service has somehow gotten folks to agree to, and we think there's a lot of advantage to that. Instead of always being asked to write something slightly different for every single customer, we want to lock down an accepted product for much of the community.

I don't know what the right number is necessarily, but I'm just saying I think advantages come from that approach. And then folks get more accustomed to the product, and then you communicate better, because ultimately, as was said earlier this morning, that's the name of the game, not just having the

knowledge, but communicating it to where someone will know what to do, and then do it.

There's also a lot of transparency here, and I don't have time, really, to get into it, but if you look down the left border, you can click on the models side, and they'll actually tell you what the models are that they employed for, say, hurricane predictions, and things like that.

They're not afraid to show you how they got to the answers or their predictions that they give you, and then it's up to you to accept them or not, and they do this using competing models. For hurricane forecasting, they use two predominant models, and they'll tell you the pros and cons, and why they do it.

We need to do more of that kind of thing and get back to what we learned as we became technologists—I'm not sure how many folks in the audience are scientists or engineers, but to me sort of a core value of a scientist is that you share your information, and you let peers critique it, and we have to do that if we're ever going to get any better at the business that we've been asked to do.

Some of the key comparisons when we started building this briefing, a year or so ago, were just striking, things I hadn't really thought about. And as we've worked through it, it became more and more analogous to the things that we're doing. The Weather Service folks, they put satellites into space. They employ weather stations to download information the same way we do for

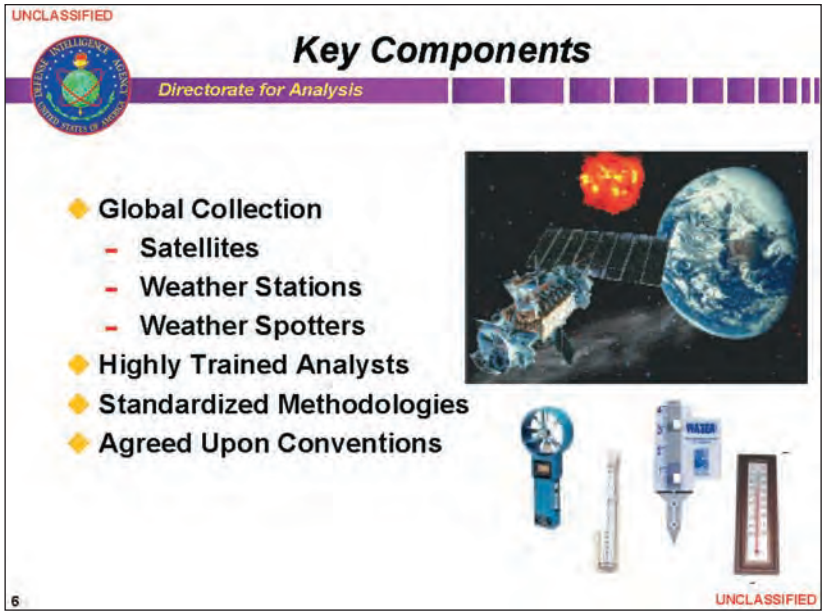

Figure 86. Key Warning Components. *Source: Author.*

imagery and other data. They have weather spotters, folks who aren't part of the National Weather Service who contribute information, who will call in.

I remember growing up in Florida. Hail storms were not prevalent, but occasionally you had bad hail storms, and they would kill cattle and things like that, and someone maybe on a farm would actually be on the evening news and would be saying, "Look at this large piece of ice that was falling," and contribute data to the system.

We could do that also if we were a little bit more clever, and again, some of the comments this morning come to mind, such as, "Why does it always have to be just the folks within the IC that are engaged? Why can't we engage a larger base?" and that's one of our stated goals in the system that we want to build.

The agreed-upon conventions are something that, in my opinion, are hurting us. We have a hard time coming to agreement on thresholds and on when we should warn. There's maybe no real right or wrong answer, but at some point you have to be pragmatic and say, "We have to draw a line somewhere, so let's do it."

The example I normally use, but for time's sake I can't go into it, considers how, if you look at hurricane forecasting, there are five categories of warning. They're tropical storms up until they get to be 75 miles and hour. From that point on, they're Category 1, with thresholds for each subsequent category. The numbers, I'm not even sure how they arrived at them, but they've been agreed to. Everyone accepts it, and it's a very useful model. We use it all the time, and no one debates it. We have to get to that point, I think, in the Intelligence Community on certain types of warning, or we'll be forever arguing with ourselves about what the perfect threshold is and never really get about the business with which we're supposed to be engaged.

The four product lines that are the principal lines used by the National Weather Service are listed here. There are forecasts, watches, warnings, and alerts, and that's a very nice paradigm to carry forward into our system. Transparency, of course, is a stated goal.

The weather folks have guts. You have to at least give them that, even if they are right only 70 percent of the time, which I believe is how they assess themselves, their own accuracy in their weather forecasting. They will let you see the data.

If you want to see the radar imagery like in this case, they'll show it to you. They'll also show you the cartoons that came out of their models. They're not afraid for you to see that. I think we need to do more of that, as much as we are allowed to.

This technology warning system that we're proposing we believe would span the space of technological development all the way from the time when it's

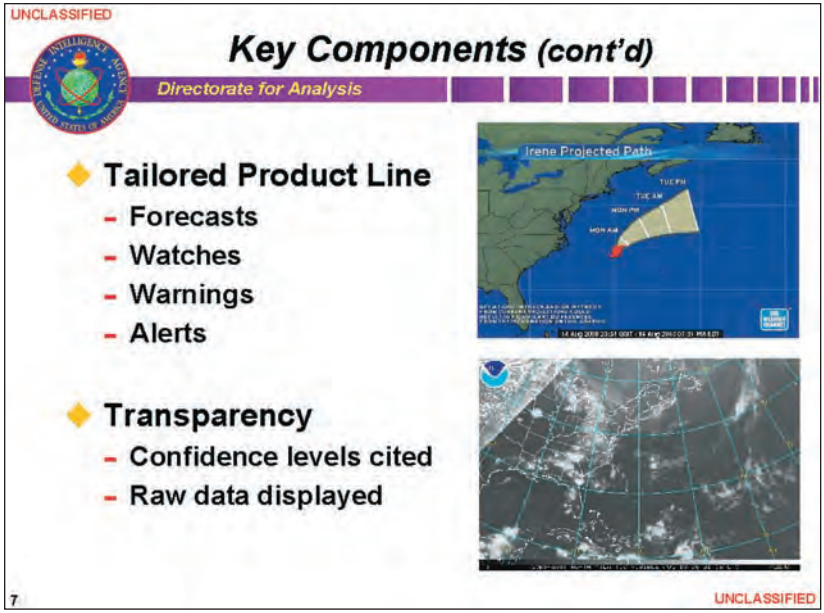

Figure 87. More Key Warning Components. *Source: The Weather Channel,* NOAA, *and the Author.*

being developed in a laboratory, maybe in a university, to the point when it's being deployed in a military system out in the field.

And so that's all we're trying to show here is notionally the forecasting—something which is not done a lot right now—is to look at what fundamental research, fundamental science might contribute in the future, and then as we see things arise which seem very important, and might have some kind of military impact, then we establish a watch.

And if you remember the language that usually comes with weather warning, a tornado watch or something like that, it means that conditions are right, if you recall the rhetoric that goes along with that type of watch. And then we could issue warnings and alerts as things become more urgent and progress in time. If we don't do that, then I suppose surprise is inevitable.

We are getting some help, and I know there was a lot of discussion about that this morning about. If you're going to do a good job of this, especially doing open source type work, and most of the work we're doing in our office is open source derived to some degree, you have to have people help you. And we've engaged with the National Academies of Sciences for about three years now, and in one of their studies that they produced for us, this was an approach that was recommended, that we need to be careful how we define the technologies we're watching.

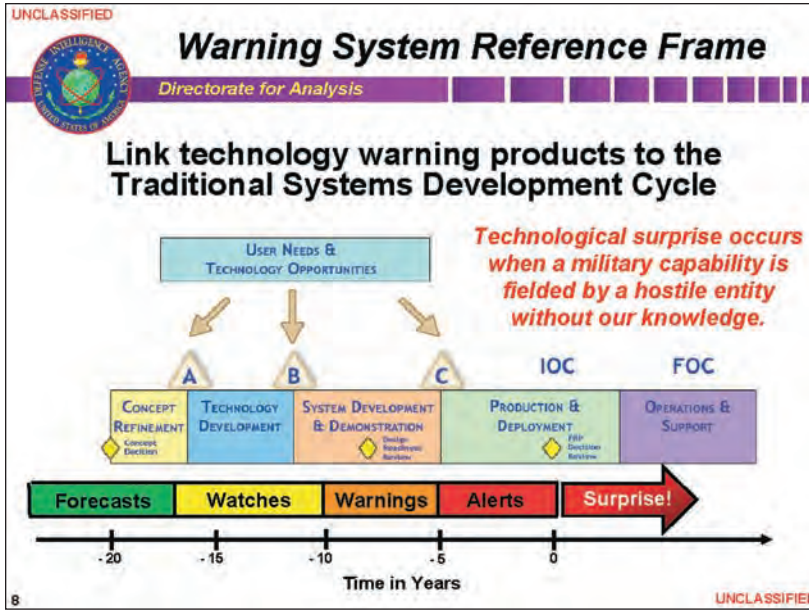

Figure 88. Warning System Reference Frame. *Source: Author.*

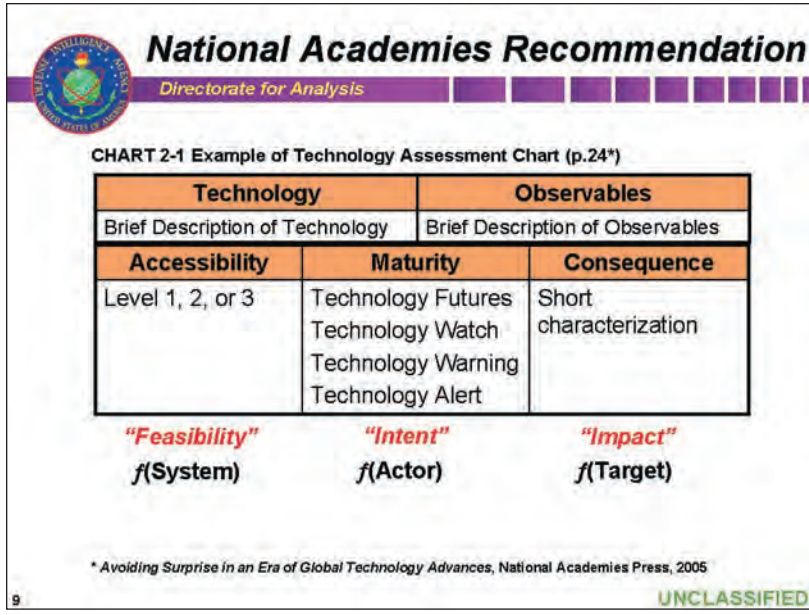

Figure 89. National Academies Warning Recommendation. *Source: Author.*

We need to have observables that we can actually track. Those should be identified up front and early. And then the last part of this, which was sort of standard operating procedure within the Intelligence Community, is that we're going to look at it to see if it's possible to do something about it. Is it feasible? And not just what would be the impact of that thing if it happened, but the intent, as well, and if you had those three things merged together, I believe you could do a fairly good job of setting up warning schemes, and that's what I'm trying to show in the next slide. And this is just a notional slide, but can you imagine a day—and you've got to really put your imagination cap on here—imagine a day when we could think of our decision warning logic, a priori up front, before there's any political pressures applied, and then, when the real crisis comes, it becomes just almost mechanical in issuing and making the right decisions?

And I would argue to a large degree that's not what takes place now. A lot of decisions are made when there's a lot of angst. There's a lot of stress, and under those conditions, at least for me, is not when I do my best thinking. So we're trying to get out in front of the problem a little bit more.

This warning matrix might look something like this chart, and if that looks J-2ish to you, good, because that's what I was trying to convey, only not as tactical as the J-2 type warning systems that a lot of you are familiar with. We want to do something that's looking many more years out.

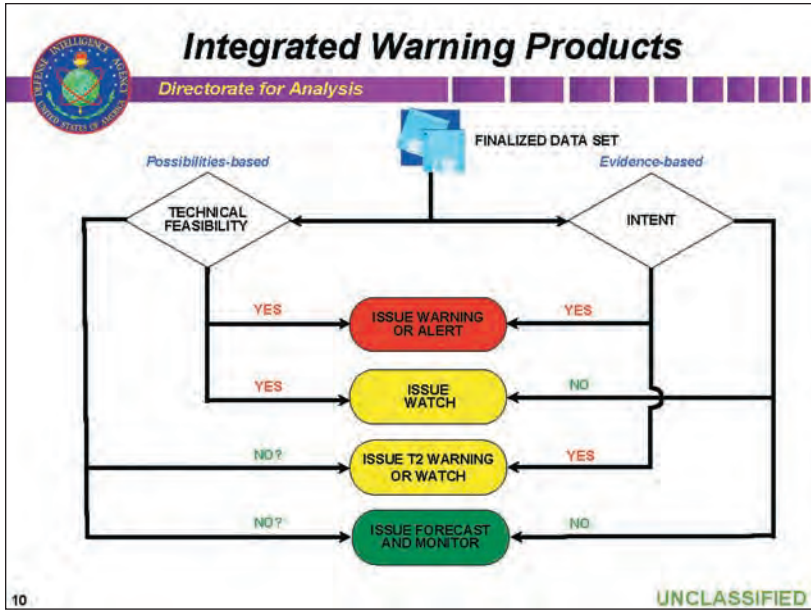

Figure 90. Integrated Warning Products. *Source: Author.*

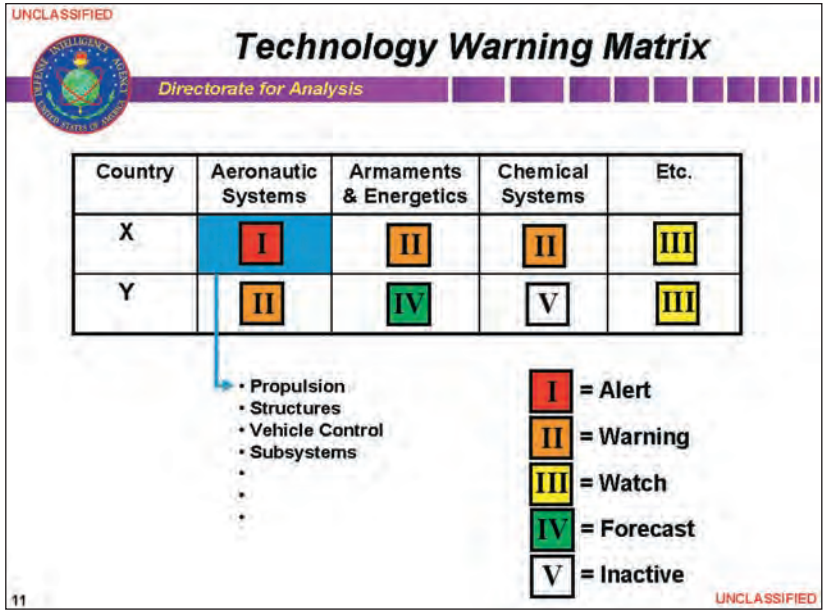

Figure 91. Technology Warning Matrix. *Source: Author.*

So what's the final vision? I'm trying to capture it in one slide. We're hoping to build a technology warning system some day that issues four principal products that spans the space from things when we're doing fundamental research in the laboratory all the way out until it's in a fielded weapon system.

We want to do that, and we want to communicate with a larger base, I think, than the S&TI community has ever reached before, and that's why, if you look at the bottom, we intend to put this system on NIPRNET so that folks that work—by the way, folks that work in the service department in their laboratories normally have access to hardly any classified information at all, and they certainly don't have SIPRNET or JWICS sitting on their terminals. I know, because I spent most of my career there.

So we've got to find a way to communicate with these folks, all the way up to JWICS, which might be the internal IC preferred method of communication. Most of the policymakers have SIPRNET, so again we're trying to recognize right up front if we're going to communicate well, then we need a system that can actually address that, and with everyone engaged.

And then with the last part in the top right-hand corner, we're saying that we want to be gutsy enough, like the weather folks, to actually track how good we are, and that, in my mind, is something that's a little novel. If we're going to make a prediction that something is going to happen, or we think there's going to be a big trend change in five years, then I think after

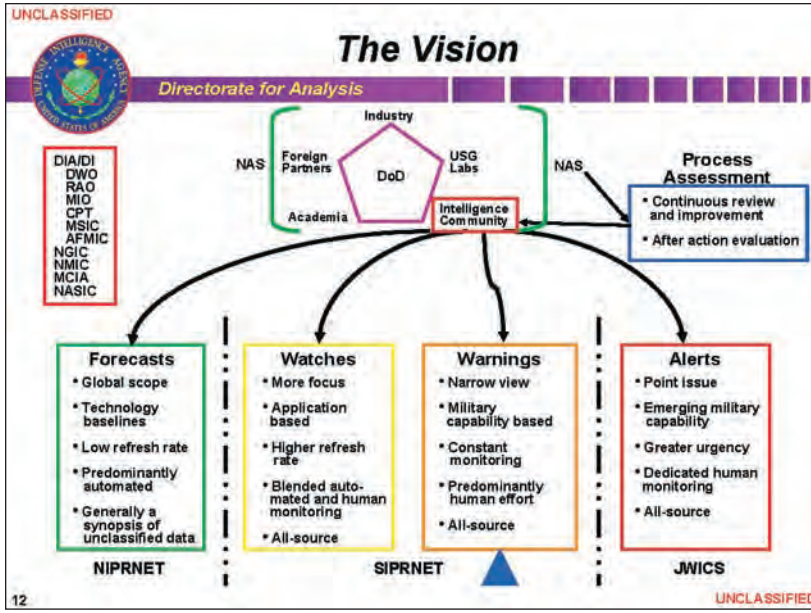

Figure 92. The Vision. *Source: Author.*

five years have passed, we ought to go back and see if we were right, or if we were wrong, and why.

I mean, we certainly don't have god-like knowledge, so none of us is trying to pretend that we can do a superb job at prediction, but we ought to be able to do something reasonable to at least help bound the problem, and that in itself, I think, would help contribute to our national security.

So, again, my last summary slide here is why this approach will be better. It's integrative and collaborative, and the part that appealed to me most, it said it's a proven, well-known paradigm that we don't have to educate anyone about, because folks are so familiar with the weather warning system, you don't really have to tell someone what a forecast is. They already intuitively know that. You don't have to tell them what an alert is, because they know what the urgency of that is. It's been probably ingrained in them since they were a young child, so, we are trying to borrow from other places and not have to invent anything that new.

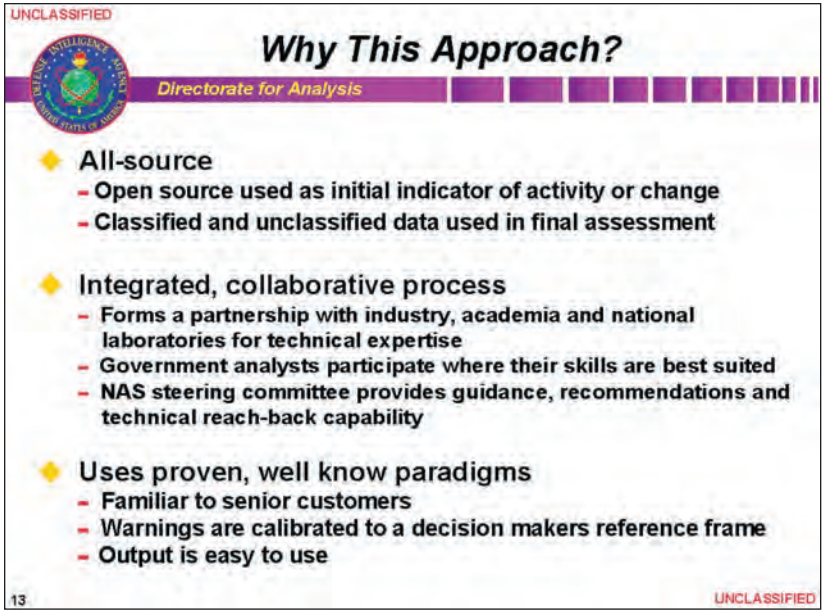

Figure 93. Why This Approach? *Source: Author.*

The last thing I wanted to say to you is that we're on the verge of doing something pretty neat if we can get help, and it's a revolution in a sense, at least for doing technical futures type warning. I think the revolution has begun, and I invite you to join us. Thank you.

"Terrorism" is a Wicked (not Tame) Problem The Role of S/T in the Future Intelligence Enterprise

Dr. Gerry Yonas
Vice President and Principal Scientist, Sandia National Laboratories

I WANT TO BEGIN WITH AN HONEST declaration in the interest of open disclosure. I am a card-carrying physicist, so for this I apologize, but I have to tell you that if you're expecting me to talk about physics, mathematics and technology, I will get there eventually. But if I run out of time, I want to repeat what we heard from most of the other speakers, and that is the role of science and technology is only a very small part of the future in dealing with terrorism. So, if I don't make any point at all during this talk, that's the point.

Dr. Yonas opens up to conferees.

I have a lot of artwork in this talk, because you may forget the words, but I think you might remember the images, and that's something I do in my group, and I have a full-time artist working in my group, and when we talk to each other, he sits there with a sketch pad, and he draws a little picture. And I think the images have a lot to do with remembering the message.

I said in the title that terrorism is a wicked problem. When I was growing up, wicked was meant to be evil, but today, anybody who is under 30 uses the term wicked to describe something that's good. Consequently, wicked could be a confusing term. So in order to be clear about it, I want to make sure you know when I'm talking about wicked, I'm talking about the opposite of tame.

Rather than define wicked, I've defined tame. When I went to school, everything I learned about engineering and physics was always tame, and the way I learned to solve problems is gather data, analyze the data, formulate the solution, and implement the solution. This ladder-down approach to solving tame problems is what I learned.

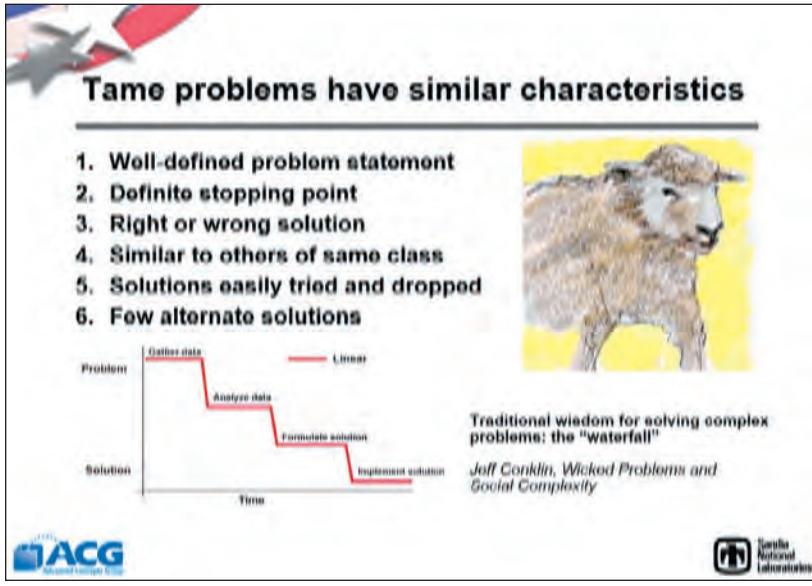

Figure 94. Tame Problems Have Similar Characteristics. *Source: Jeff Conklin, Wicked Problems and Social Complexity (CogNexus Institute) (http//cognexus.org/wpf/wickedproblems.pdf.)* and Author.

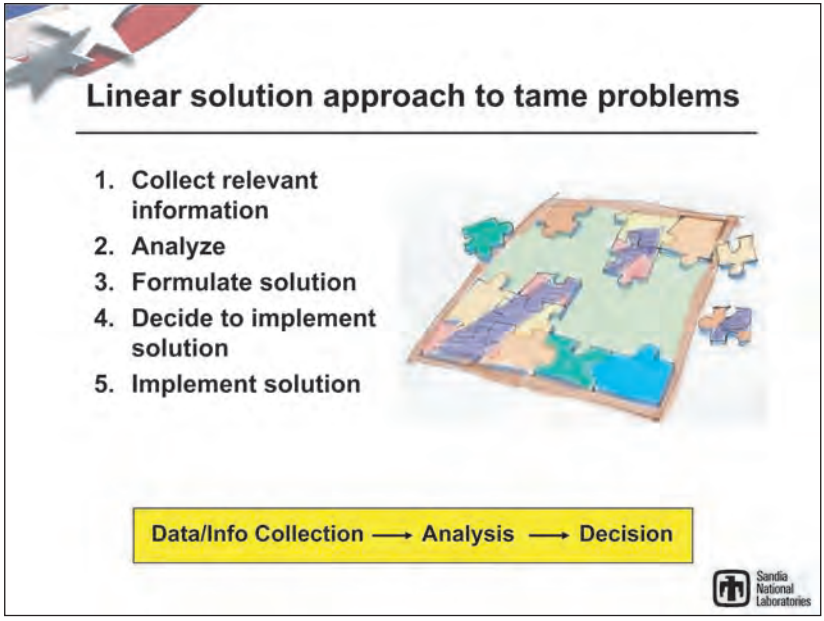

Figure 95. Linear Solution Approach to Tame Problems. *Source: Author.*

A characteristic of these kinds of problems is that the problem can be defined. And when the solution is implemented, it's over. There is a right or wrong, and you can classify a whole bunch of problems in that class of tame problems where only one or two clearly defined solutions exist.

How about a show of hands? How many people in this room learned to solve problems this way? Well, now you know why we have a difficulty here. The difficulty is that most problems we face today are not tame, and we're still trying to solve them in tame ways.

What we try to do is treat the tame problems as if they were linear, going all the way from collecting data, to analyzing, formulating solutions, and to making decisions. And I read something the other day that General Hayden said we need to somehow combine collection and analysis. You did it—almost had it right.

My view is you have to connect data collection, analysis, and decision-making. If it's linear, you can break this up, do these things sequentially, and implement the solution. But if the problem isn't tame, if the problem is wicked, this doesn't work.

What happens is that when you start to get a solution of a wicked problem, it suddenly rebounds. The problem reacts against you, and you go from euphoria to depression. You're back in the problem again. I'm sure you've had this experience lately where you go, "Oh, I thought I had it, but that's not it."

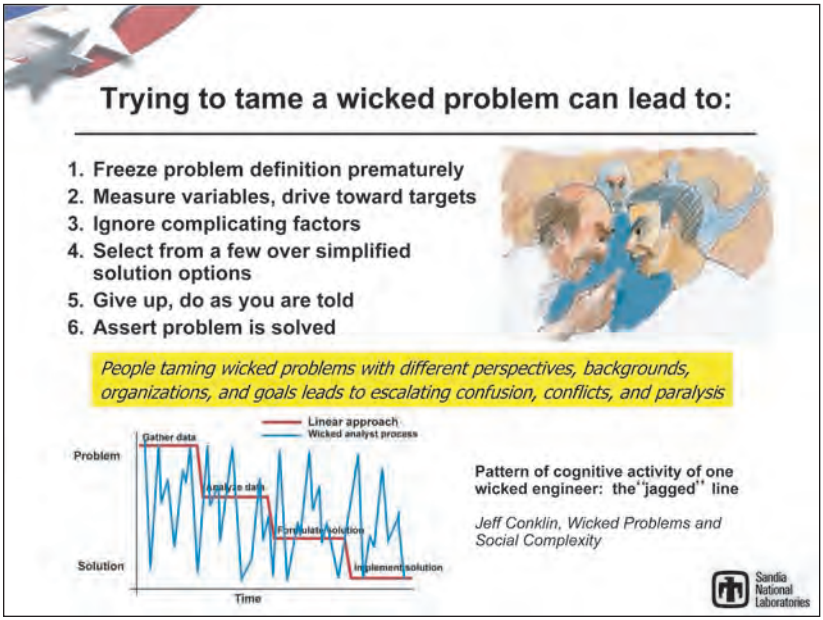

Figure 96. Trying to Tame a Wicked Problem can Lead To. *Source: Jeff Conklin, Wicked Problems and Social Complexity and Author.*

What happens when the problem really is wicked, but you pretend that it's tame and you define it too soon? You jump to conclusions. You measure a few variables. Your boss says, "Go get a solution. Deliver me a product," and they're metrics. People are gauging how many of something you turned out. When you're faced with a schedule, and you have to have metrics, you ignore the complications. And when things start to not work out very well, just do what your boss told you to do, and say, "Problem solved," and blame your boss.

This problem of oscillating between problem and solution where the problem is pushing back on you, is something that is very bad when you have just one person, but can you imagine where you have a whole group, and all working on different schedules in terms of going through euphoria and depression? What do you get? You get this kind of picture.

So how do you know that you're somehow mixed up with a wicked problem? Well, there's something that you can listen for. If somebody in the room says, "If we could only get clear roles and responsibilities and put somebody in charge," if you ever hear anybody say that, that's the number one symptom that you are in the middle of a wicked problem where people are behaving as if it were tame.

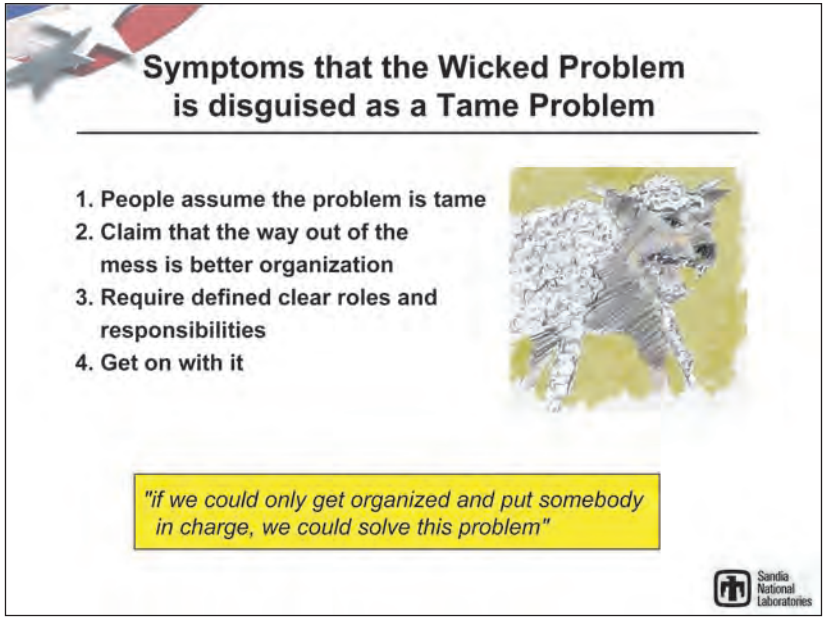

Figure 97. Symptoms that the Wicked Problem is Disguised as a Tame Problem.
Source: Author.

Has anybody ever heard this expression, "If we could only get organized and put somebody in charge"? That's when you know you're in deep trouble, and I'm not going to make any political comments, so let's go on. So this is quite hopeless, and so it's time to just bag it and take off the rest of the afternoon.

But maybe there is a way out. One of my favorite system thinkers is Jamshid Gharajedaghi, who's a Persian. He wrote a wonderful book that's almost impossible to understand about system thinking, but the number one rule in his book is formulate the mess. Formulate the entire contextual mess. Try to understand all the variables. Under-stand the context.

If you remember nothing else from this talk, remember the rule, "Formulate the mess," and do that first, and if you're really trying to do this, you can't do it all by yourself. You have to have a team, and the team has to be committed to a spiral, not a linear process. And a spiral process goes data collection, analysis, decision-making, back to more data, and you may have to go through this over and over and over again, and the faster you do it, the better off you're going to be. But don't try to get the right answer. Just do it, and spiral.

If you're with a team, the entire team needs to formulate the mess together, and they have to share the context, and then they have to communicate. Another rule from Gharajedaghi is that success is the devil. If you ever

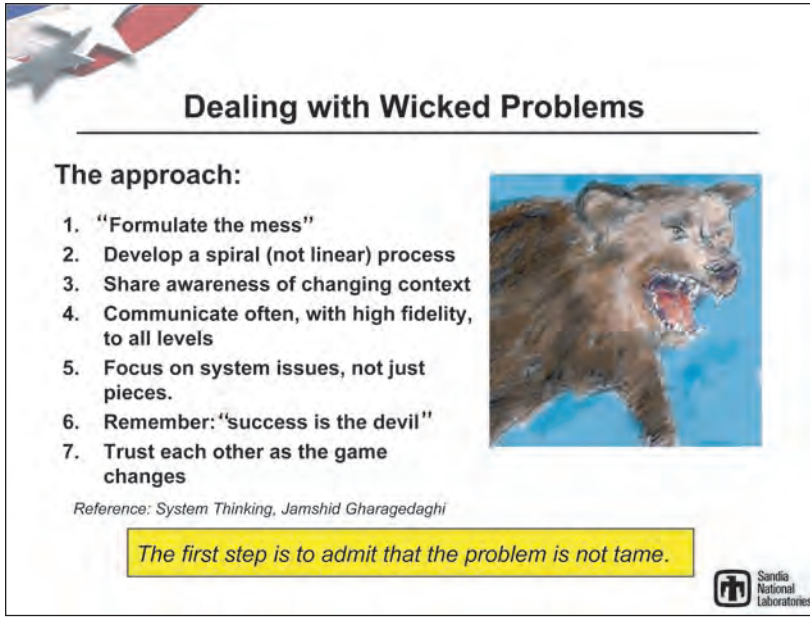

Figure 98. Dealing with Wicked Problems. *Source: Jamshid Gharajedaghi, Systems Thinking. Elsevier: 2006.*

did something, and it worked out, don't try to apply the solution again if it's a wicked problem. It won't apply.

The ancient philosopher said you cannot step into the same river twice. Well, it's also true you can't step into the same river once, but—and the contrary version of "success is the devil" is "failure is the devil"—so what does this get you? It says don't jump to conclusions based on your past experience.

But the hardest thing to do is admit you're involved in a wicked problem. Everything we're talking about in this room today is wicked, so admit that from the get-go, and that's the way to start. Now this is not a very optimistic approach. It's not linear. There's a lot of feedback. It requires a group of people. The group has to trust each other, and the people have to share some common understanding of the problem. That's very hard, but if you don't do that, it probably is hopeless.

Now what makes this difficult is this notion of "The Long War," and as military intelligence people thinking about the conflict phase, it was sort of straightforward. Our goal was to impose security, but now when we're beginning to think about a long war involving a long period prior to conflict, and possibly during this period we can avoid conflict, or if we go into conflict, a

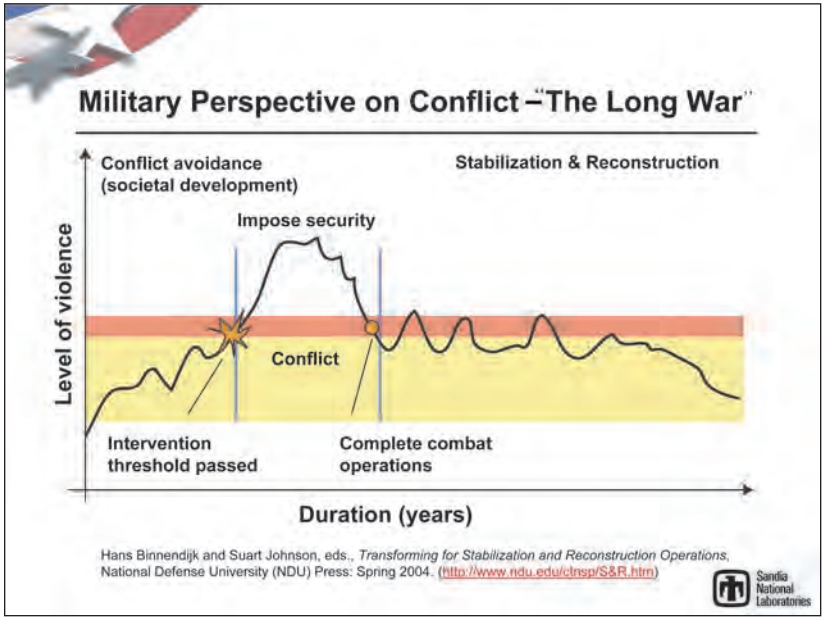

Figure 99. Military Perspective on Conflict — "The Long War." *Source: Hans Binnendijk and Stuart Johnson, eds., Transforming for Stabilization and Reconstruction Operations, National Defense University (NDU) Press: Spring 2004.*

period where there is some restoration of normalcy, but not complete, and there may be a much longer period after the conflict than before or during.

So this idea of a long war requires a tremendous emphasis on understanding political, social, and economic factors. It's not just about the weapons used in the conflict, so this makes it even harder.

As our future adversaries learn more, what we're finding out is that they have all kinds of tools at their disposal, and when I used to work in the business of trying to understand the Soviet Union, the focus was on strategic weapons. At least, my focus was on strategic weapons, and as we moved forward in technology, I got interested in anti-satellite weapons, which was a bit more challenging but still a fairly linear problem.

But now we're facing irregular weapons, and the irregular weapons can be something as simple as an IED by the side of the road. This should not come as a surprise as a tool of irregular warfare.

But the next category that we're facing that's even more difficult is sociological weapons, and, for instance, a financial attack or a military coup that doesn't go the way we expected, or a race war in some other country where we're all of the sudden in the middle of it. When I wrote this, I didn't really think

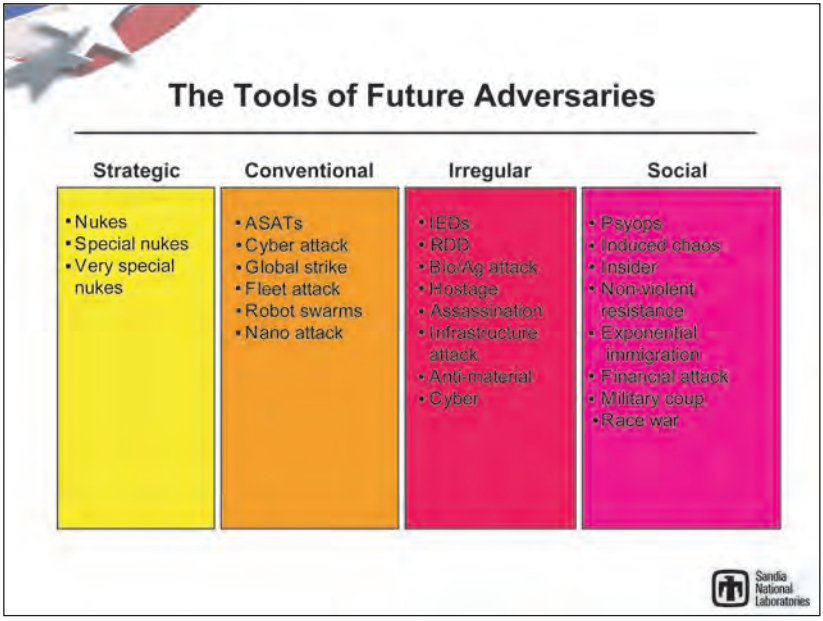

Figure 100. The Tools of Future Adversaries. *Source: Author.*

about the right words. This would probably have been a secular war in another country. And so the tools of sociological warfare are really the most challenging and the most wicked of all tools that our adversaries can use.

So let's talk about what our adversary really is trying to do. It may be that we have made much too much about terrorism. Maybe this is really not a big deal, and the real problem is not the terrorism, but the terrorized. And maybe it's our reaction to terrorism that is really our enemy—the nonlinear impact.

So, for instance, let's just look at this idealistic view of a very brittle, organized society with small bumps. Now that kind of a brittle system can be subject to very large transients, phase changes, changes from healthy economy to a depression. Another possibility is this brittle society could go from a stationary state to chaos.

If our adversaries can drive us through a nonlinear transition or into chaos, we've lost. So my view is this is the enemy. It's what we do to ourselves as a result of small changes from our adversary where we have forced ourselves in a position of inflexibility and brittleness in the way we respond.

On the other hand, if our adversary—let's say it's a totalitarian state, rigid, formal, hierarchical, inflexible—it seems reasonable that we should be able to drive that society into a nonlinear transition, and I think we know how to do that. We did it with the Soviet Union, and the tools of our defeating the Soviet Union were really in the hands of the Soviet Union. We just

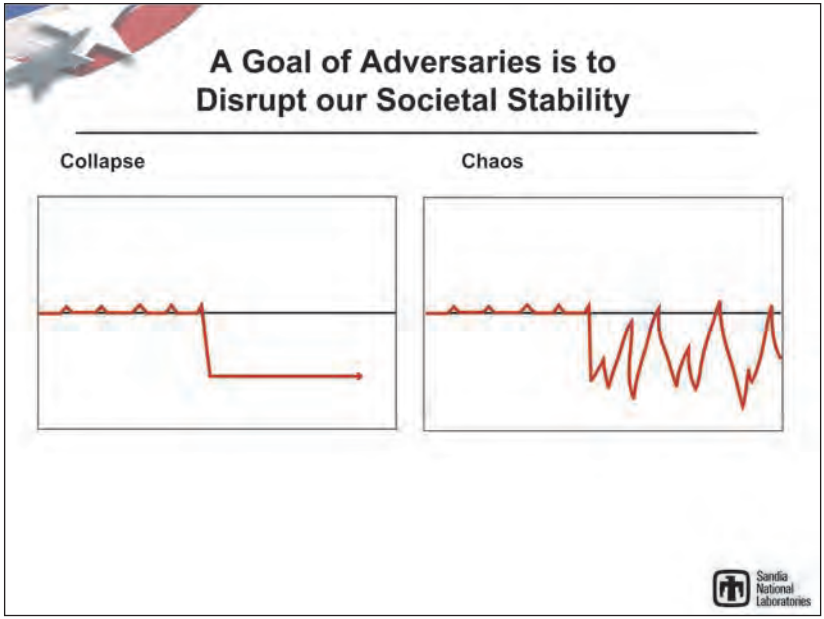

Figure 101. Disrupting Societal Stability. *Source: Author.*

helped them do it to themselves. So why can't we learn from this in looking to our future adversaries?

You knew I had to say something about technology. I run a small group, Advanced Concepts Group, and several years ago when I started this group—it's getting to be about six years now—I made a projection for technology futures, and I started with the three revolutions in Nano, Info, and Bio, and I called that NIB tech.

When it all comes together, and they begin to reinforce each other, then technology advances very rapidly, followed by Cogno Tech, and then beyond that Socio Tech. And that seemed a bit ambitious when I drew this about seven years ago.

NIB Tech happened almost immediately, and Cogno Tech, really understanding the brain and being able to build technology around neuroscience, is already happening. We didn't have to wait out here until 2030. It'll be here in 2020, it's going to happen in 2010, and I just imagine Socio Tech can't be far behind.

So the ability to make predictions is tough, because it has to do with the future. In fact, that was Yogi Berra who said that, a great American philosopher, but I was way off in my predictions, and these developments are really speeding up very rapidly, and the aspect about this that you need to think about in terms of military intelligence is this is open to everybody. It's not just avail-

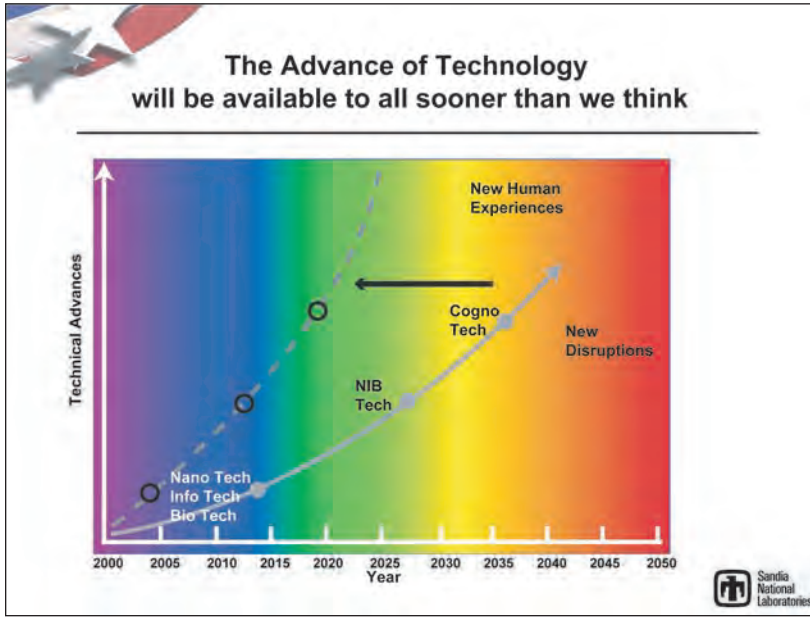

Figure 102. The Advance to Technology. *Source: Author.*

able to us. It's open to our adversaries, and if we let them get ahead of us, that poses new threats.

So what's driving this rapid escalation? We already heard this today. It's being driven by globalization of knowledge, it's infotech, available instantaneously. In the mountains, in the caves in Bora Bora, they're downloading the latest information. I can't be sure, but I'm willing to believe anywhere in the world you can collect the kind of information that you used to have to collect by going to civilization.

And we're becoming so dependent. Not only is this a very vital factor in terms of global knowledge, that interwoven fabric of widespread information technology, this may offer the most difficult vulnerability for our society in the future, if we don't think about the kinds of attacks against our info infrastructure.

The area that I think is going to be even more important, as we heard earlier from Dr. Colwell, is biotechnology and the biotechnology revolution. The underpinnings of that is information technology, and I think that the drive for biotechnology and biomedicine will be driven by people of my ilk, namely geezers.

And at the same time that technology is rapidly advancing for disease prevention and health maintenance, this possibility of bioweapons is

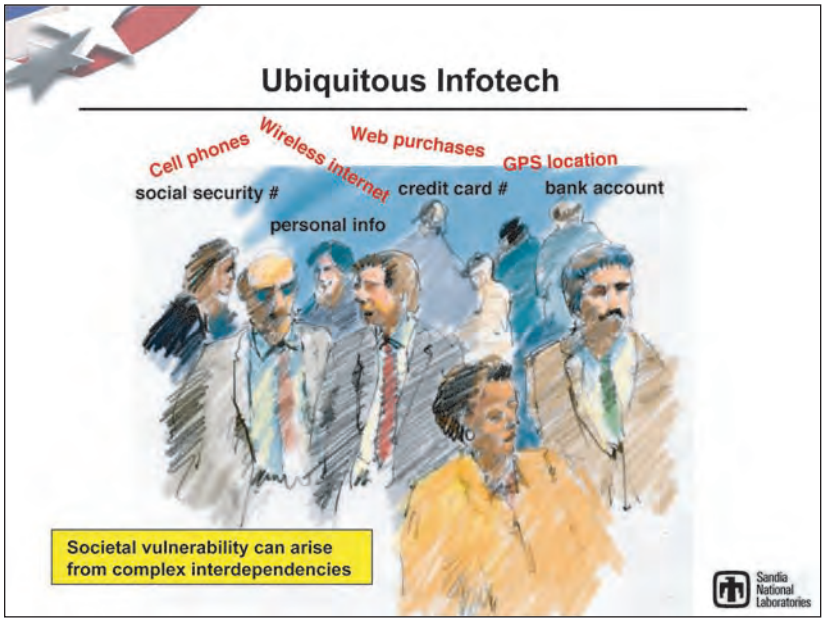

Figure 103. Ubiquitous Infotech. *Source: Author.*

going to be very real, and I think it's going to be very tough for the Intelligence Community to keep up with the rapid advances in biotechnology. How do you do that? The answer is you have to form some kind of alliance with the broader community.

The next one after biotechnology is cogno technology. Cogno technology hasn't quite happened yet, but it's going to because of tremendously improved understanding of how the brain works as a machine, mostly through imaging, high resolution time and spatial imaging of the brain, functional imaging, but also coupled with computer modeling of how the brain works. And then in addition to that, these small, smart machines that will become the neuro prosthetics of the future.

There'll be all kinds of social, economic and ethical issues about the rapid advance in cogno technology, particularly in behavior and cognitive enhancement. If you think there's a controversy over sports medicine and extreme athletes, what happens when we have tools for creating extreme scholars? Who gets it? Who owns it? What are the rules? Your kids get to go to college and take advantage of this stuff, and the other kids don't?

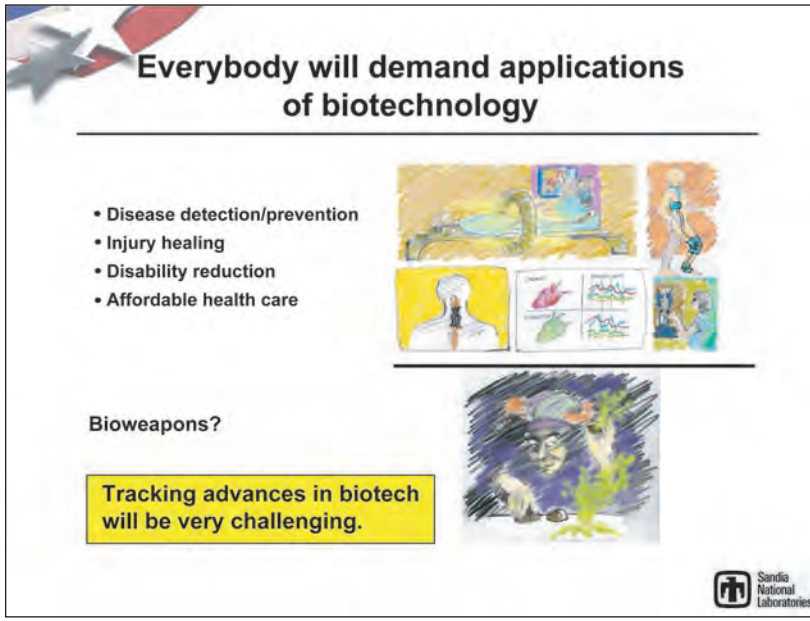

Figure 104. Biotechnology Applications Demand. *Source: Author.*

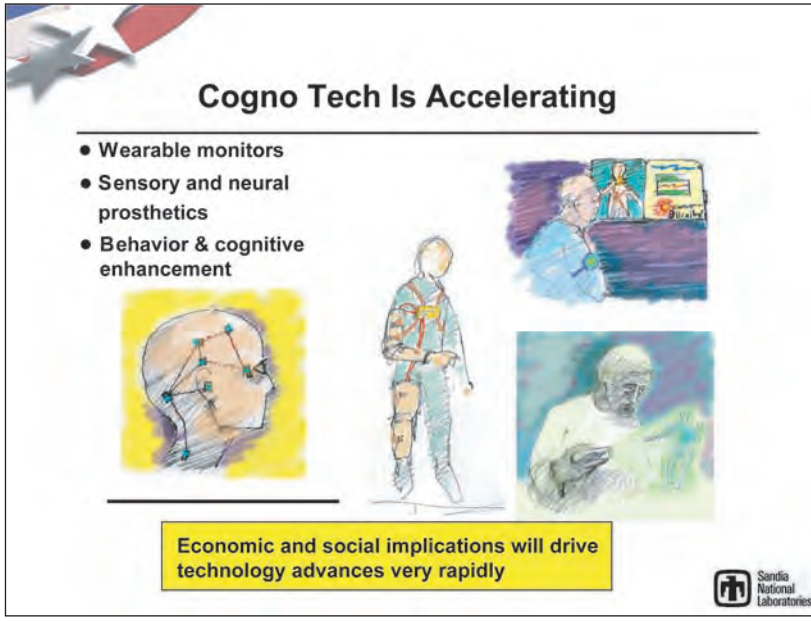

Figure 105. Cogno Tech Acceleration. *Source: Author.*

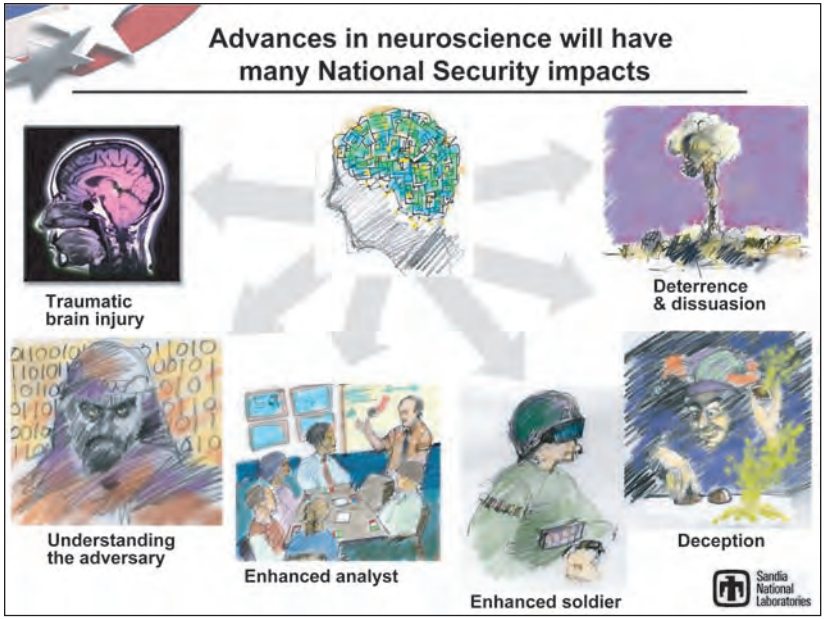

Figure 106. Neuroscience Impacts on National Security. *Source: Author.*

So these issues, these broad issues, will affect our society. We think this way, but I'm not so sure that other countries will think the same way, and that may change the rate of advance in that technology.

So underlying all of this is this rapidly growing field of neuroscience. If there is one technology, one science technology that I think we need to watch, it's not widgets and gadgets. It's not airplanes and hypersonics. It's the underlying science that will come from understanding the brain.

An example would be what we're discovering now about soldiers coming back from Iraq, that historically people have been subject to concussions and been diagnosed as having stress problems. But more than likely, that's a physiological problem that can be diagnosed and understood and treated once you know what the problem is.

Understanding the adversary, helping our analysts, helping soldiers, these are all the bright sides of applications of neuroscience, but there are other areas that could be not quite so nice. But neuroscience is going to play an important role in the technology over the next ten, 20 years.

So this neurospectrum goes all the way from understanding and helping to enhancing. When you get to enhancing, it gets to be a bit more controversial, and the next step is degrading, causing damage. And when you get to this situation, it becomes questionable whether or not it will be

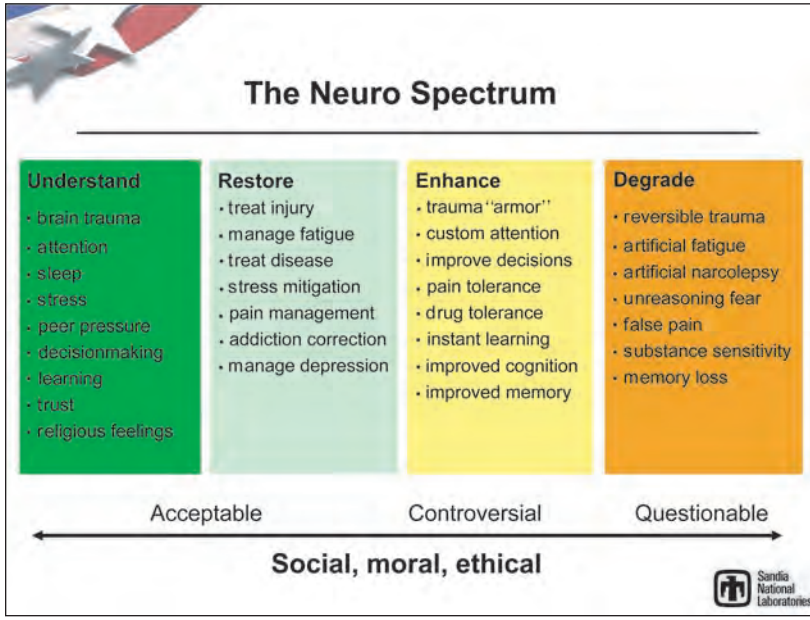

Figure 107. The Neuro Spectrum. *Source: Author.*

allowed—whether there'll be treaties against weapons that play in this arena or not. But more than likely, this kind of neurospectrum will become real over the next ten to 20 years.

So enhanced cognition will affect our lives. One of the most exciting areas is enhanced learning, being able to go from no knowledge of a subject to understanding the subject and being able to retain that information for a longer period of time. That's probably something that we can look forward to that can be done with a better understanding of the underlying neuroscience. And, of course, this image of Big Brother controlling you through your TV screen, forcing you to buy some product—well, that's already happened, but you can imagine the social and political implications.

So how will the Military Intelligence Community deal with this area of enhanced emphasis on brains, biotechnology, biomedicine, and all of the technology that involves, with time, to interact with individuals, interact with groups, interact with society? And when we think about this integrated infotechnology with people and large-scale society, you can begin to see the opportunity for large-scale vulnerabilities again. This might be an avenue for a major improvement or a mode of attack.

I spent most of my career working on beam weapons, and much of this had to do with lasers in space that could destroy a Soviet SS-18 rising, and

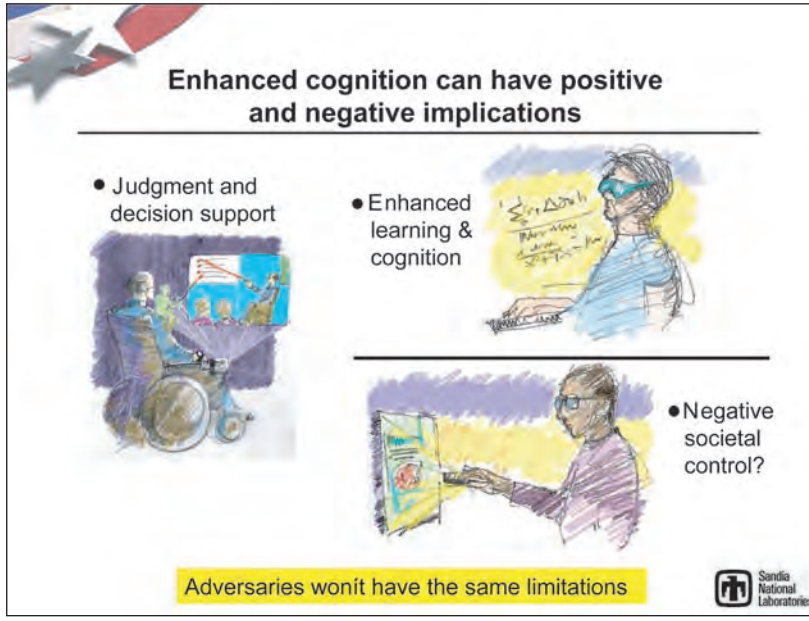

Figure 108. Enhanced Cognition Implications. *Source: Author.*

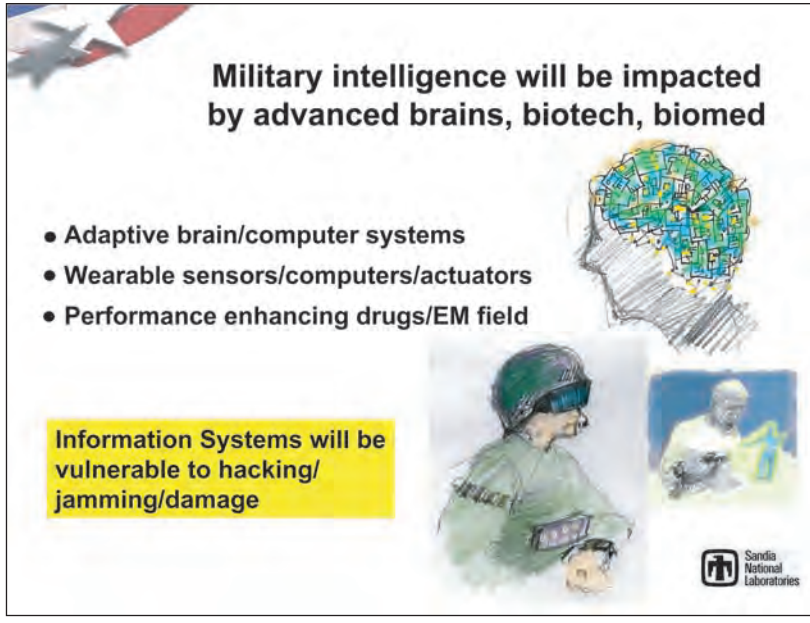

Figure 109. The Impact of Advanced Brains, Biotech, and Biomed. *Source: Author.*

Figure 110. Beams as Weapons. *Source: Author.*

when I worked on that back in the eighties, we didn't know how to do it, and guess what? We still don't know how to do it.

But I think what we missed is that beam weapons probably will not have much use against military equipment, but more than likely, beam weapons will have a major impact against people that are inherently vulnerable. And the first beam weapon that has been developed, ready for deployment, is a microwave weapon that can cause pain out at some distance, and that weapon has not been deployed. The pain is caused by heating of the skin.

But that's real, and I can picture weapons like that that can be dialed, all the way from stun to disable to kill, as a future direction for speed-of-light weapons. So this is a technology that's already here and will be evolving in the near future and needs to be tracked, needs to be understood.

Another area is the whole issue of attack without any warning. One way to do this is with very fast weapons, hypersonic weapons, but a lot less sophisticated technology is a weapon you can't see. A stealth weapon does not have to be very big or expensive. It can be a small airplane, small drone launched from a ship at sea that can fly over our coast to an American city, practically impossible to detect, impossible to defend against.

And so a real threat is caused by the use of fast flyers or stealthy attack, or frankly katushas coming from Southern Lebanon against Haifa. The first

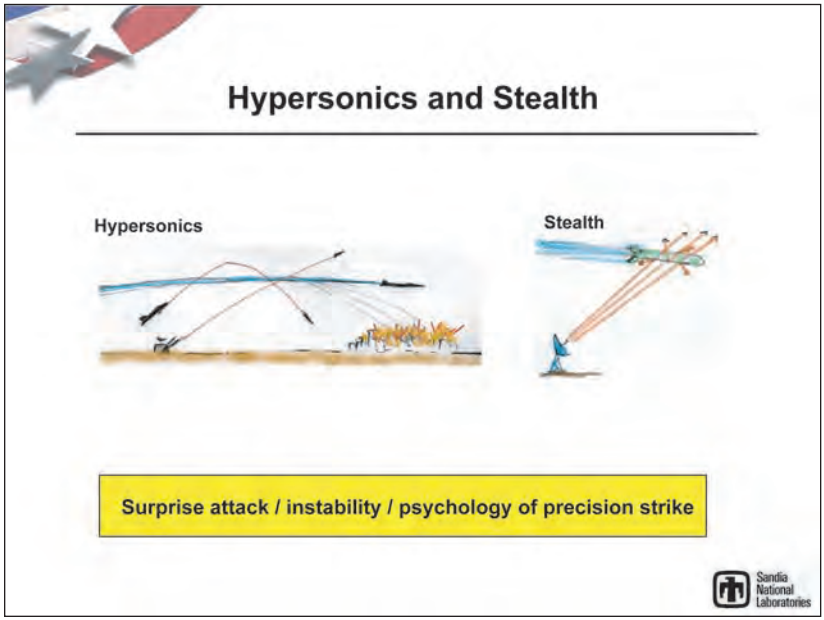

Figure 111. Hypersonics and Stealth. *Source: Author.*

thing people ask me is, "What about those lasers you guys had? Could the Israelis have used those lasers to defeat those katushas?" and the answer is, "No."

Being able to stand off and throw weapons across a boundary without any defense is something that we should expect in the future. Small airplanes can be flown for very large distances into the heartland of the United States with practically no defense, and we should expect that.

Another area that is undoubtedly going to be increasing rapidly is the use of all kinds of small, smart robots, and when small, smart robots have some small amount of intelligence, and they can communicate with each other, they can they form swarms. And if they're cheap enough and plentiful enough, and they can swarm, they can obtain precision intelligence and carry out precision attack. And this changes the way conflict would be fought in the future.

I like to describe much of what we do as lurch, lurch, lurch, and I think it would be replaced by perch, and then search, and then lurch, precision awareness, precision decisions, and then precision strike. And this is coming out of the MASINT field that we heard about earlier. This should happen in the fairly near future with small, smart machines.

So I told you earlier about this notion of a brittle society that could go through a nonlinear transition or a brittle society that can go through transition to chaos. So what's the way out of this? Well, the way out is to have a society that has dynamic stability. It has large oscillations but not chaos. It

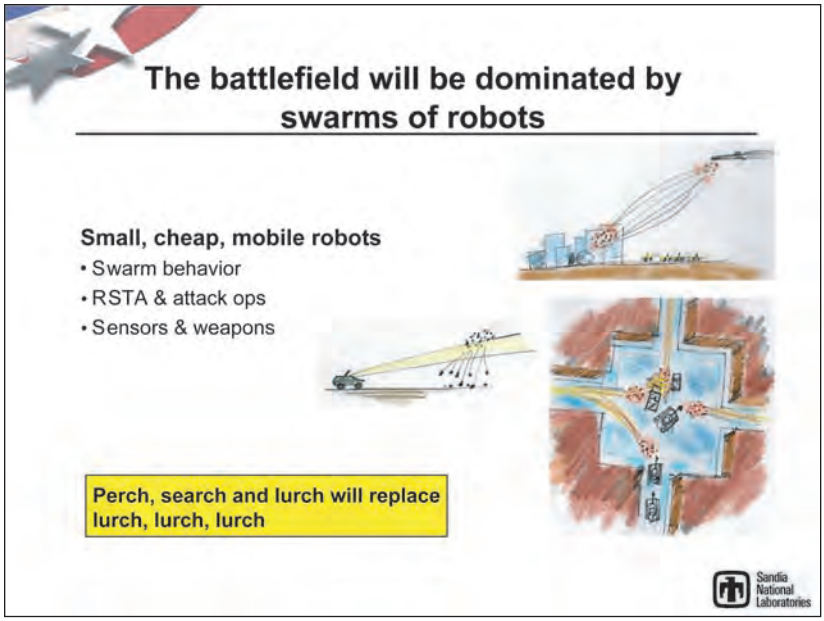

Figure 112. Battlefield Domination by Robots. *Source: Author.*

has a free and open exchange of information. It has checks and balances. It has democracy, and it may look like some level of chaos, but it's not total chaos. It sort of works.

So this could be our strategic advantage in the future, and other societies could be at a strategic disadvantage. So this is the area where we could focus our attention for having a superior military capability, but it's not just military. This future is characterized by a space, a political, economic, and sociological change. Picture this three-dimensional space, and picture societies as moving along a mountain in this space of social, political, and economic change.

Some societies like ours switch. Our trajectory is the switch back. We go back and forth across that mountain, and we do that through technology. Other societies never get off this region of poverty. Other societies take a very long time, and some societies try to move rapidly up this mountain of hope.

I don't really understand what I just said to you, but I know there's something to this, that technology allows you to move along in this space that is a function not just of the technology but your society, your politics, your economics, and the rate at which you can apply technology. I'm not sure we have the optimum approach.

I keep thinking that China is trying to race up this mountain without changing its politics very much, and to me that feels fragile. And there

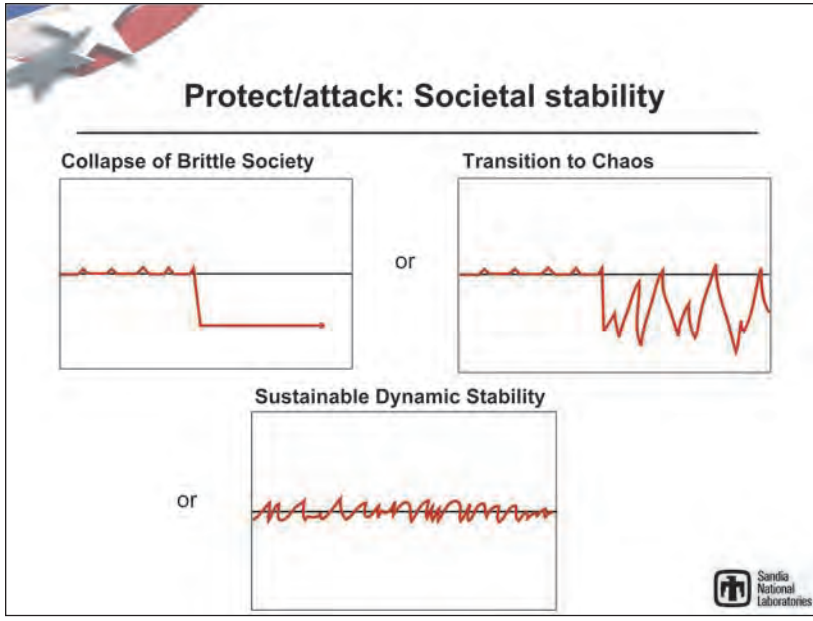

Figure 113. Protect/Attack: Societal Stability. *Source: Author.*

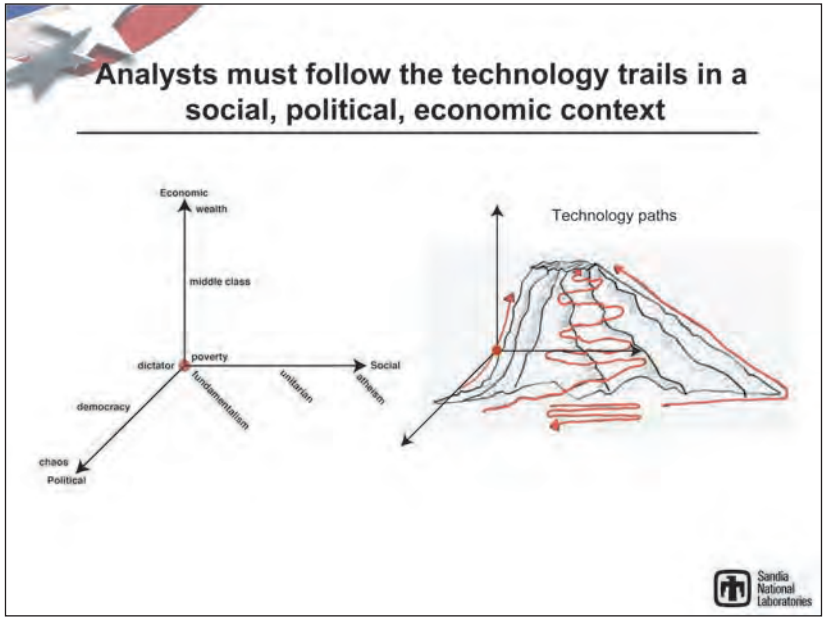

Figure 114. Technology Trails in a Social, Political, and Economic Context. *Source: Author.*

Figure 115. Our Goal should be Dynamic Stability. *Source: Author.*

are other countries like our neighbors to the south in Mexico that never can seem to get off where they are now. Their GDP is where it was 25 years ago. And there are other societies that take their time, like Portugal, and they're eventually moving up this path. But I kind of think the way we are doing it has this feeling of dynamic stability.

So I want to end on an optimistic note, and the optimistic note is that this kind of world of dynamic stability allows you to ride the crest of the wave. If you get out in front of it, you get caught in the undertow. You go too fast, and you're thrown up and down by the waves. If you fall behind, you're left out. But my feeling is that if we maintain our dynamic stability, we can ride the crest of the wave, and so I want to end on that optimistic note. Thank you.

AUDIENCE QUESTIONS

AUDIENCE: If you move the model, does it change the model? You know, you're a physicist, and I could talk about the Heisenberg uncertainty principle, and you can't measure something without affecting that thing, and like in Lebanon, we had a democracy, or some sustainable democracy. Right now I don't know what we have.

The problem that I seem to come back to is reading the mind of the adversary; if we are working in a Euclidian system, and they're working in a Reiman space system or a Lobovchesky system, where the premises are different

than ours, and we're building a model of the enemy, that is not the model that the enemy is working with.

Our society itself is not stable, because of all that technology's going to do to our society. It's going to create problems, fragment it, and bring it back together to this thing. But what do you think if the enemy is working in another space, with another way of thinking than we are? How do we find ourselves now?

DR. YONAS: I'm going to respond a bit from my history, and I was a Cold War warrior, and eventually I came to the conclusion that our dynamic stability, with all its frailties and its checks and balances and apparent chaos, is the right way, and the Soviet Union was fragile. And I didn't really understand until very far in my career how fragile that society really was.

My hope is that by understanding our adversary, truly, deeply, we'll understand the problems in their society and be able to deal with it, but we're not there yet. So understanding that full social, political, and economic dimension of our adversary, we have to do it. How can we do it? Probably have to live there. Probably have to have a very close interaction over a long time.

AUDIENCE: With respect to that three dimensional diagram of culture, economy and politics, what would be the impact of education on this, and particularly with regard to education applying to subsequent generations and to immigrants being able to integrate into a culture that is supportive?

DR. YONAS: I mentioned to you my view of Mexico is it's frozen into an economic space. Although they bounce around in the social-political space, they can't get off the ground floor in economics. And my latest conclusion, which is probably wrong, is it's their educational system. It's totally broken. There's just something terribly wrong.

I think the numbers I've heard that 50 or 60 million people never get past sixth grade, and their higher education is focused on getting a professional degree rather than doing work. There's something about the educational system. That's a negative statement about Mexico.

On the other hand, I'm very positive about the United States' educational system. In spite of the fact that we're going to hear, and we have heard, that there's a gathering storm—we don't put through enough scientists and engineers and mathematicians—I think our education system's pretty good. It's a lot of non-uniformities, a lot of inequities, but where it's good, it's very good.

If I were going to say something about education to keep us riding the crest of that wave, I think we need to change the way we train engineers. I think engineers ought to have a professional training that includes dealing with realities of the social, political, and economic factors.

In fact, I've been going to schools in the United States and advocating a curriculum of wicked engineering. If you get on Google and put in

"wicked engineering," you'll find my name, because I've been going around giving this talk, and it's not going over very well. And the primary problem is the parents don't want to pay for that extra one or two years of school. Who's going to pay for this?

So I'm trying to think about that. If we're really going to be competitive in the world of tomorrow, it's possible there needs to be post-graduate education, more than likely paid for by the employers. And more than likely, education has to be continuing over the 60 years that the average worker will work. Notice I didn't say 50 or 40.

And during this 50- or 60-year career, there will have to be continuing education, like every ten years. In fact, we see that in the military. The military often sends people back to school every ten years. Well, the engineering community, like many professional communities, needs to do that.

AUDIENCE: Architects have been solving wicked problems for years. A client comes to an architect and says, "I want my dream house." It's an under-constraint problem, with more than one feasible solution. It's a wicked problem, so their method, tried and proved, is the architect offers suggestions. The client evaluates and chooses, and they cycle, just as you suggested.

My suggestion is if you think about wicked problems in general, you ought to think also about roles and responsibilities, that the analyst should not also be evaluating and judging. That's a conflict of interest. You end up with a distorted output. If you set up roles, client role, analyst role, you can end up with much more productive solutions.

DR. YONAS: Well, I'm opposed to clear delineation of analyst-collector. Let me tell you why. I used to do experimental physics, and whenever we had the theoretician separate from the experimentalist separate from the boss, it was linear. It didn't work. We made mistakes. It was slow, ponderous.

But when we got the three together in a room and fought with each other and went through this spiral process where everybody had their responsibilities, but everybody shared ideas and argued with each other, we made real progress in this kind of architect-client world, but with a spiral process. That's worked for me. That's what I'm advocating.

AUDIENCE: The argument is a separation of responsibilities, which is just what you were describing, that the experimentalist is not trying to play theoretician.

DR. YONAS: But the experimentalist, in my world, in complex physics, the experimentalist had to really understand in great depth what the analyst was doing, and the analyst had to understand in great depth what the experimentalist was doing. And even just as important, the boss who had to make a decision about what was going on—are we going to keep doing this—had to understand all of it.

And so it became a group activity, and that's what I'm advocating. There are responsibilities, a tremendous amount of sharing, and if you're going to share, you have to trust each other. So if you're going to do this, you have to start off with all agreeing on the context, so you spend a lot of time formulating the mess, agree on the context, and then a lot of sharing. But this linear process, collecting some data, handing it to analysts, handing it to a decision maker, doesn't work for wicked. It works for tame.

AUDIENCE: Do you have any thoughts on how our educational programs need to change to address wicked problems?

DR. YONAS: Yes. The question is what would I seriously suggest, and I've gone to some universities lately and talked about how you would change the curriculum. Now the standard approach to getting engineers to think about wicked problems is to have them take a course in British literature or painting. That's not what I'm talking about.

I'm talking, for instance, about putting together a project team with freshmen, and defining the problem in a very open-ended way where you bring together kids who are studying sociology, studying political science, studying medicine, studying engineering, to work on a real problem together. I think architects figured this out a long time ago.

Put together an architectural oriented team to work on a problem. Start in the freshman year, and maybe keep the team going for three or four years to work on a very important problem where they'll find out there really is no solution, and they'll go through exuberance and despair and oscillate around and eventually figure out what it's all about.

The other thing I would suggest is this continuing education where you say, "We can't do it in four years." So every ten years, we all go back to school for a year, you know, when we're 50, when we're 60, when we're 70. At some point, you've got to retire, although there won't be any money for that.

It's a wicked problem. That's real wicked. It won't be because of Social Security. It'll be because of health care costs, which will bankrupt the country, but we won't get into that.

But having a program of continuing education, more than likely paid for by the employer, probably has to be the way to change the education system of the future. It doesn't have to be where you go back to school. You may be able to just do it at home. Distance learning is probably the wave of the future. Now there won't be a football team, but you can't have everything.

AUDIENCE: I'm interested to know your thoughts on the financial implications of wicked problem management. How do you budget for wicked problem management where the world doesn't really understand budgeting for management?

DR. YONAS: Wow, this is tough. So how do you pay the bills when the problem is wicked, and there aren't any metrics, and the first thing you find out is the original approach doesn't work, and all of the sudden it's crashing and burning, and the budget estimate is blown? How do you live with that? How do you manage that economics?

I'd put a lot of slack in the budget estimate to begin with, but I think what you really have to have is the bill payer has to be part of the team, and there has to be a high degree of integrity. Can you imagine that, high integrity defense procurement?

So starting off with very high integrity requires that the buyer and the seller really exchange the honest truth about how tough the problem is, the fact that it's wicked, what the challenges are. A lot more money has to go up front during the mess formulation phase, and you don't make promises that you can't keep and then walk away from later on. Integrity's got to be the answer, and a lot of shared pain and shared understanding.

AUDIENCE: A follow on to that is that I've heard that going into the future that the powers that be, the budget, the money people, are not going to fund research or put resources to solving wicked problems. Do you think that's true, and if so, what are we going to do?

DR. YONAS: Well, I'm going to take an optimistic view of the future, and by that I mean if we have a high degree of open disclosure and honesty and integrity about these problems, we say, "Yeah, we could do this, and we could silver plate it, and it's going to be doing that, and it'll be this big, but it'll cost this much money," and we don't really know how to do it.

But let me tell you what we could do. We could set that goal, long-term goal, and we will put together a series of hurdles. And the first hurdle won't cost you very much, but during that phase, early phase, we'll be resolving issues, the most difficult issues. And if at the end of a year or two we haven't resolved those issues, we'll agree to terminate that program and not go forward.

So there has to be a different way of budgeting, planning, based on confronting the issues first. I call that pushing for the drop-dead decision, not for the go-ahead decision. Push for the early out. Show it can't be done.

I used to say when I had my short stay in the Pentagon that we ought to promote the military, we ought to give somebody a star if they managed to show a program that's futile and had it cancelled. Can you imagine that? Could you imagine promoting somebody because this program is futile, and we need to cancel it?

AUDIENCE: That did happen one time, not at the Pentagon, but I got a briefing on that, and they had to make a real command decision, and he stopped the program.

DR. YONAS: And did he get promoted?

AUDIENCE: He's still around.

AUDIENCE: I might be able to kill two birds with one stone here. First of all, I agree with you that you have to have that engineer-scientist-analyst interaction. That's based on some 44 years in the Intelligence Community where we'd actually sit down with the analysts and say, "What are you doing?" And they'd tell you, and you'd say, "Well, gee,"—that's not right?

And they'd say, "Can you give me this?" and you'd say, "Well, yes, how much is it going to cost?" "$2.35, but would you like to have this? It'll cost $7.50," or something like that. That's where you get the real synergy in this thing.

The other thing I'd like to point out is that when Mr. Pappas was talking this morning, we kind of beat the Intelligence Community over the head about things they aren't doing. I want to assure you that at the tactical intelligence level you have all kinds of interaction.

Every flag—I personally attend at least two VTCs every week where every flag up there is represented as part of those groups, interfacing with the people on the ground in Iraq, in Afghanistan, helping to solve their problems, all kinds of interaction between these organizations. So let me tell you folks, it's there, okay? Now, at the strategic level, it may not be, but I'm telling you at the tactical level, it is, okay. Thank you.

AUDIENCE: I like your talk in perspective a lot, but I do want to suggest to you one gap, which is you barely mentioned the social sciences. Are the sciences the only ones that really deal with wicked problems? And, in particular, one of the interesting issues is the way they've become much more enabled by technology and can actually be much more rigorous sciences than they were, say, 20 years ago, though they're still woefully underfunded.

I think one has to incorporate into this perspective, as you anticipate the future, where investments in social science can take us and what kinds of investments we should be making.

DR. YONAS: Well, let me respond to your point about respect for the social sciences. I only have ten, 11, 12 people in my group at any one time. We have two cultural anthropologists, two political scientists, one historian, and a nuclear engineer, half of the population in this small group is in social science.

We don't have a bonafide computer-oriented social sociologist, and so if you know of a really good combination computer scientist-social scientist, I think that would be a big step forward. I'd like to meet that person.

AUDIENCE: I guess it's a technical question. What is the feasibility of designing a system to detect explosives on the body of the suicide bomber, and even better, to explode it from a distance?

DR. YONAS: Okay, I think the problem of standoff explosive detection requires an active interrogation approach. In other words, you have to put energy out and then look at the response of the energy you put out. Now even

if you put energy out, and you interact with the suicide bomber, there has to be a signature caused by sending the energy out.

For instance, let's say there is explosive contamination on the clothing. The energy goes out and excites the material, the trace chemical species, to fluoresce, to radiate, and then over here you have a spectrometer, a gadget that takes a picture in a wavelength that responds to the fluorescence of the trace chemical species.

I'm positive that will work. There's only one problem. What if that explosive bomber is very neat, washes his hands, changes his clothes, nothing on the skin, nothing on the clothing, but only underneath the clothes? Then you have to have something that can penetrate through the clothing, cause the material to interact and give you back the signal.

Petty Officer Jermaine Armstrong and Dr. Gerry Yonas pause after sharing ideas at the Conference finale.

There are forms of energy that do that, but they tend to be penetrating radiation that causes other problems. You may not want to put penetrating radiation on the average person walking down the street.

AUDIENCE: It's happening anyway?

DR. YONAS: Like neutrons. But there may be other forms of penetrating radiation, and I saw in the MASINT talk that there is a meeting on penetration. You know, I was very interested. I want to see what is it that you're going to use for that kind of active interrogation.

The second part was let's say you detect an explosive. Then what do you do? Well, if it's in the middle of a crowd, do you want to set it off? So there you may want to have some way to diffuse or interrupt that process. These are huge scientific and technical challenges, but I don't think it's impossible. How's that for a non-answer?

Speed Kills

Dr. Eric Haseltine,
Associate Director of National Intelligence for Science and Technology,
Office of the Director of National Intelligence.

MR HIPONIA: DR. HASELTINE is responsible for leading the Intelligence Community to a coherent science and technology strategy, one that ensures IC dominance and one that uses world-class R&D processes.

He has served as Director of Research at the National Security Agency and is Executive Vice President of Research and Development at Walt Disney Imagineering, Disney's R&D division. Ladies and gentlemen, please welcome Dr. Haseltine.

Dr. Haseltine makes a point.

DR. HASELTINE: Thank you very much. It's a great pleasure to be here this afternoon. I understand that you've heard a fair amount of biology

today from Rita Colwell, who is, after all, a biologist, and you're going to hear some more.

And, in fact, what Mr Hiponia didn't say is that my background is in neuroscience, a kind of biology, and in neuroscience, you're captivated by a single question. Why is that organism not a fossil? What is it about its brain that makes it still reproducing and eating and doing all the other things that living organisms do and not extinct?

And the reason I want to use that as a metaphor for doing an entree here is to point out that if we look at our business and us in the Intelligence Community as a biological organism, I would posit to you that we have undergone traumas on the order of asteroid hits.

In the Permian extinction of three or so hundred million years ago, something like over 99 percent of all species on the planet were wiped out, probably by an asteroid or a comet. And I would posit to you that we have been hit, not by one, not by two, but by three metaphorical asteroids that would affect our business and have profound implications for science and technology.

So asteroid number one that is shaping our environment was the fall of the Berlin wall and the collapse of the Soviet Union. And from a biological point of view that changed our prey and predator environment radically. We were no longer preying on stegosaurus and being preyed on by tyrannosaur, but now we had tree shrews and rats and weevils and insects and all kinds of things, in other words, terrorism.

You know, Jerry Boykin said of Russia during the bad old Soviet days, "easy to find, hard to kill." You know, that tyrannosaur ain't too hard to find, but kind of hard to kill. Now the problem is hard to find, easy to kill, right. I mean, after we found Zarqawi, not a big problem. So asteroid number one is that the entire equation for our environment has radically changed on both sides of the eat-them-or-they-eat-you side of the equation.

The second asteroid was 9/11, because not only did our prey and predator change, but they moved inside our turning radius. They are now here in America—a paradigm shift our institutions are very ill equipped to deal with.

This whole issue of what is domestic intelligence and foreign intelligence used to be a very important and meaningful distinction. Not that it isn't today, but when someone in Syria talks to someone in Iran on MSN mail, where does that traffic go? Is that purely an international event, or is it partly a domestic event, or does it no longer matter? So asteroid number two is the demolition of geography, if you will, and with it, for example, the emergence of transnational threats, about which Al Qaeda is the first and most prominent, but I dare say probably not the last.

Can anybody tell me what the third and biggest asteroid of all is for technology? Well, I'll tell you. How many of you have heard of Danny Hillis?

He's a Turing Award winner. He sat next to me for five years at Disney, and on the other side was Alan Kay, also a Turing Award winner, so what happened to me? Well, I ended up a spook, right?

But here's the deal. Danny Hillis has a very interesting way of looking at the human condition. He has what I would call a 200,000-year PERT chart, which is about the incidence of the creation of knowledge and information, and it's very interesting when you look at things on that scale.

What do you think the slope of the knowledge creation curve was for the first 199,000 years of human existence? Pretty flat. And what happened with the written word around, what, 5,000, 6,000 years ago, maybe more? They just found some stuff in Latin America, and the dates are nudging up. And then what happened with the printing press? The Internet. And on a 200,000-year scale, what does that look like? Does that look like a steep ramp? It's a vertical wall.

So what's happened is we're going along as a species and, boom, the information explosion. So in a very real sense, the environment that we navigate, where we prey and are preyed upon, is the information environment, and what has happened to the information environment? It has radically changed.

THE PROBLEM OF SPEED

- *Knowledge created in the 1990's is equal to all knowledge created in 300,000 years of human history to that decade.*
- *NSA estimates that the internet will carry 647 petabytes (billion million bytes) of data EACH DAY in 2007. For comparison, the Library of Congress holdings represent 0.02 petabytes.*
- *Estimated that in 2010, the cost of synthesizing bacteria genome-sized DNA sequence will be equivalent to the price of a car.*

Figure 116. The Problem of Speed. *Source: Author.*

And so we have those three convergences all happening at the same time. And what is the prime directive? What is the imperative for survival when your environment changes? The old adage is mutate or die, ergo the title of my speech.

What I'm going to talk about is the overwhelming problem of speed. And by the way, I have my deputy here, Steve Nixon, and a lot of these ideas are due to him, so if you don't like them, it's his fault. The ones you do like, obviously, were my brilliant ideas.

Our view is that the essential problem—and I use the example of dinosaurs willfully, and I'm going to horribly mix metaphors and talk about other pachydermish-like creatures to paint the analogy to us—is that we're just too

TRENDS

- *Internet users grew 183% from 2000. 1 billion users last year. 2 billion by 2011.*
- *2 billion cell phones this year. 3 billion by 2009.*
- *Wireless "hotspots" grew 87% in one year. Now 100,000. 200,000 by 2010.*

Figure 117. Trends. *Source: Author.*

Figure 118. Global Technology Diffusion. *Source: Author.*

slow. If you go and take my analogy a little further, if I'm coming up against a tree shrew or a scorpion or some nasty little critter, if I'm too slow to turn on him, I'm in deep trouble, and that, we believe, is the heart of the problem.

And we're going to also get into a diagnosis of why we have the problem, and then we're going to try to open up a little ray of hope to say we are actually on the case and trying to do something about it. At the end of the day, we want to enlist your help in this.

It's not by accident we agree to give speeches like this. We have an agenda, and it's not hidden. Our agenda is to radically transform the way we

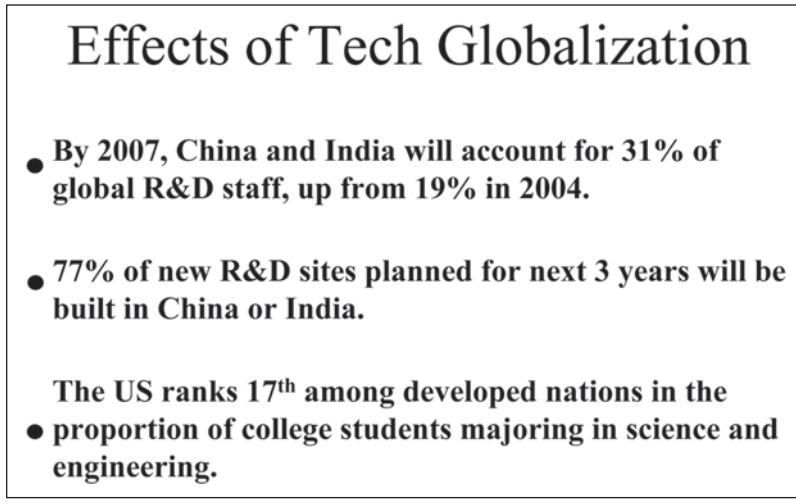

Figure 119. Effects of Technology on Globalization. *Source: Author.*

Figure 120. Declining U.S. Trade Balance for High Technology Products. *Source: Task Force on the Future of American Innovation based on data from U.S. Census Bureau Foreign Trade Statistics, U.S. International Trade in Goods and Services. Compiled by APS Office of Public Affairs.*

develop, deploy, and use technology to solve our intelligence problems, and by radical I mean we want to go from ten years to ten months or ten weeks.

Let's talk about the problem first, and I'm just going to let you read this, because you can read it faster than I can say it, and after all, we're about speed. (see Figure 119) Yes, things are happening fast, and a lot of them aren't happening over here. No. See, we're accelerating. The pace of change accelerates.

This is really depressing. This isn't our general balance of payments. (see Figure 120) This is high tech. We now have a negative balance of payments, 30-some billion dollars high tech, and if you guys really want to be depressed, get the "Rising Above the Gathering Storm" of the National Academy, which was issued earlier this year. It has all these fun factoids in it and many, many more that will make you want to put a bullet in your head.

So let's get to the heart of the problem here. The Japanese and the Germans may not have realized it at the time, but by bombing their industrial base into oblivion, we in a sense did them a favor, and what was that favor? A clean slate. They started with new stuff.

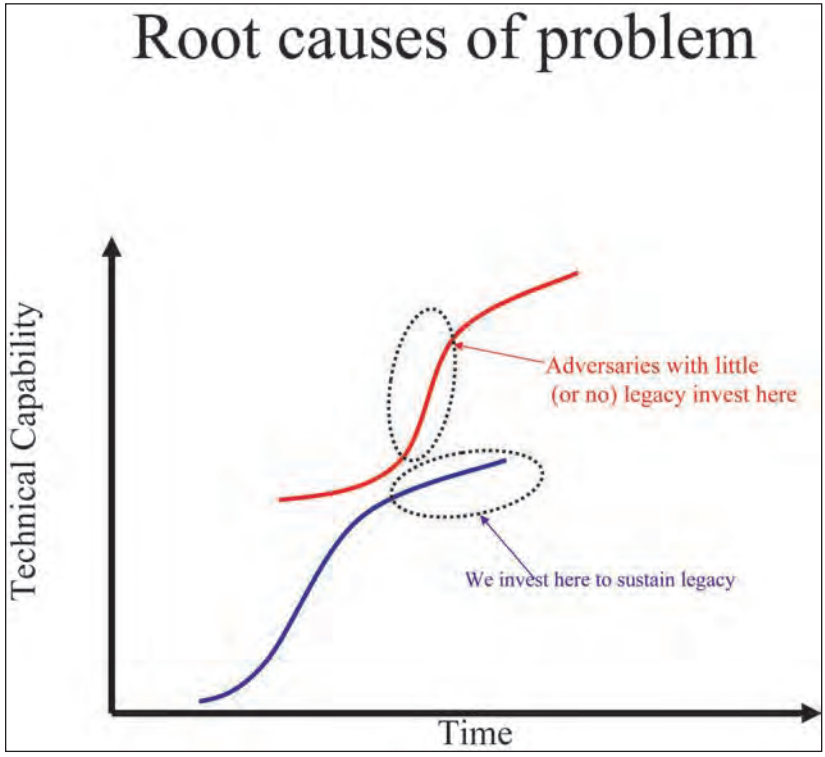

Figure 121. Root Causes of the Problem. *Source: Author.*

So we're over here cranking out stuff, rusty old infrastructure, steel mills, and they invent mini-mills. They do things much quicker. Essentially, while we, because we were not bombed, were clinging to the legacy of our old industrial infrastructure, and by the way, during the fifties, kicking some major butt, because we had no competition in the international scene, because we had destroyed it all during the war, but all of the sudden, competition started rearing its head, because now these new factories started coming on line.

And then all of the sudden, poof, no more consumer electronics. Poof, no more steel. Poof, Ford doing what Ford is doing. We are living with that today, because to a certain extent, this is a gross oversimplification, but you can see Ford's problem is maybe being a little more associated with that blue curve versus the red curve. (see Figure 121)

And let me give you a very concrete example of this when it comes to our business information technology and intelligence information technology. The Internet, which we invented and therefore are clinging to the legacy of, pretty much today is what's called IPV four. But there's this new thing called IPV six, which China has already rolled out, and we're still thinking about it.

And then, of course, we have a lot of wired technology investment. A lot of countries are skipping right to three or three-and-a-half G cell phones. Forget pods, and I could give you many, many examples of this. The fact of the matter is being a first mover has big advantages, and it has big disadvantages.

If you magnify the intersection of those two curves, the red curve and the blue curve, what you see is that the gap in any given epoch of time between the red and the blue grows exponentially. And one other way to look at it, if you imagine animal analogy again, we're kind of a dinosaur or a pachyderm, kind of lumbering along that blue shallow curve where we may invest ten years and $10 billion to get a ten percent improvement in overhead resolution, for instance.

Whereas, we have this explosion in new technology where some much more agile creature like a tree shrew or some other, you know, agile arboreal animal, is just scampering up that curve. And I have a very classified version of this that gives you very concrete example of where the top targets that we now worry about today that are in the newspapers are on this curve ahead of us.

It's very depressing, and the problem is we seem to be in no danger of getting it, that despite all the evidence to the contrary, I'm not going to mention the country, but there is a big, big, big bureaucracy that is not normally associated with efficient government, and they have beaten the pants off of us at getting new technology out the door. It is very sobering stuff, and so we have to take a sobering look at that.

If you translate this, there's a famous chart at one of our agencies that shall remain nameless in which it looks at all the different very classified programs they've had over the years. And what they do is they have on one side of

the chart years to public disclosure. And it started off in the sixties, where it took 38, 40 years for the public to find out that we were doing this thing.

And then over successive generations of this certain kind of technology, they've looked at over the years, what's happened to time to disclosure, and you know what it is today for this particular new kind of program? How long before—minus eight years. We haven't even put it out there yet, and it's already blown. Oh, there's another interesting correlation with that chart. It shows number of people read into the program.

The original, it was like single digits were read into the program, and today it's a single digit plus eight zeros or something. Literally, there could be several hundred thousand people read onto these TS/SCI programs, and guess what? Time to leak decreases directly in proportion to the number of people who are read in. Hmm. I wonder if there's a relationship there.

But the point is this. We take forever to do incremental technology that isn't really going to surprise anybody, and then they know about it before we deploy it, and they've already got their counter long before we've ever deployed the thing. Maybe it's possible to counter hyperspectral technology with silicon dioxide technology, known as dirt. Just throw a bunch of dirt and maybe a little reinforced concrete on it. Done, especially when you do it before we launch, if, in fact, I were talking about overhead.

But the point, I think, is made here that many bad things happen when you pile a lot of dollars and a lot of years onto doing a program. First, you cannot be agile if you're going to take that long. Second, you're going to blow it, because you've got too many people on it, because you're spending a lot of money, a lot of people are cleared, a lot of people are going to talk, and they're not going to know it.

So you're going to get there late with something that's incrementally improved that the enemy already knows about. And, oh, by the way, you spent $10 billion on something. What didn't you spend it on? I'm going to dwell on that point for a minute and ask a group of questions. So I'm going to ask you to go from reverse to forward here, so put in the clutch, and get ready for me to point a finger at you and ask you a question.

In September, 1939, Germany invaded Poland, and then roughly five years later, we invaded France. So if you take a comparable period of history and compare, and I ask you the following question. Between 1939 and 1944, what new technology—just on the Allied side—forget the Germans or the Japanese—what revolutionary new technology, and by revolutionary I mean fundamentally transformed warfare, something that you could never dream of doing before that was hugely decisive and impactful, how many new technologies were there? Radar. Sonar. Computers. Yes. Right. That's true. Oh, nuclear weapons. Did I forget nuclear weapons? Oh, those.

Well, true, but 1945, give or take. The point was okay, let's cheat. Let's cheat and say 1940 to 1945, okay. All right. Always a trouble-maker.

Okay, so now let's take a comparable five-year period, 9/11/2001 to 9/11/2006. In the war on terror, what revolutionary technologies of the same transformative nature that we had in World War II have we brought to bear on the war on terror that were as revolutionary as nuclear weapons or radar?

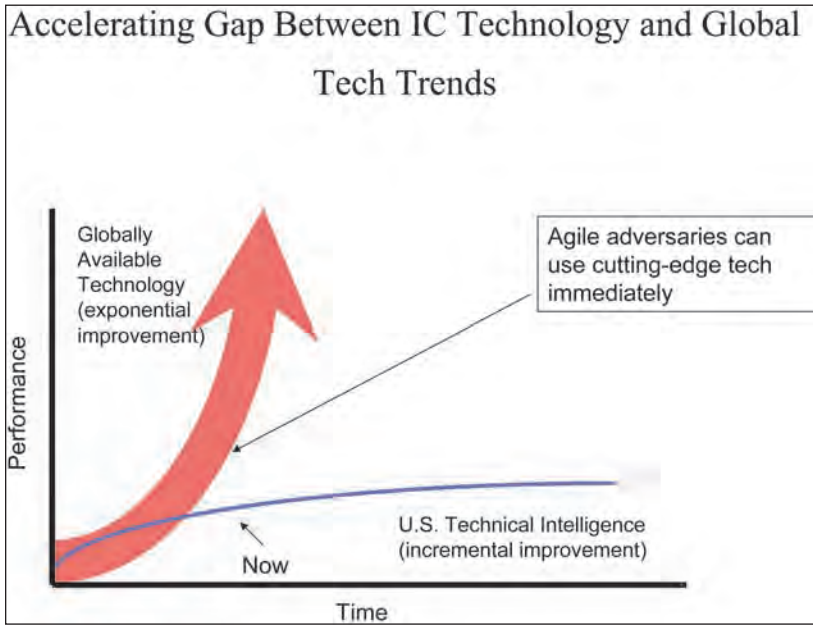

Figure 122. Accelerating Gap between IC Technology and Global Tech Trends.
Source: Author.

PARTICIPANT: Data money.

DR. HASELTINE: Data money. Ooh. I think you understand my point, and here's something to make it even starker. What was the pace of technological change in 1940? Did we have Moore's Law in 1940? Did we have Metcalfe's Law? Did we have the incredible speed of collaboration?

PARTICIPANT: We had 40 percent of GNP going into the military.

DR. HASELTINE: All true.

PARTICIPANT: No television, either.

DR. HASELTINE: Yes. No MTV, no Jerry Springer. Okay, but it is an interesting question when you kind of take a step back, and you say, "Now wait a minute. The pace of technology and innovation has increased several orders of magnitude between 1940 and 2006, and yet our pace of innovation has slowed way down. And one of the really sobering questions we have to look in the mir-

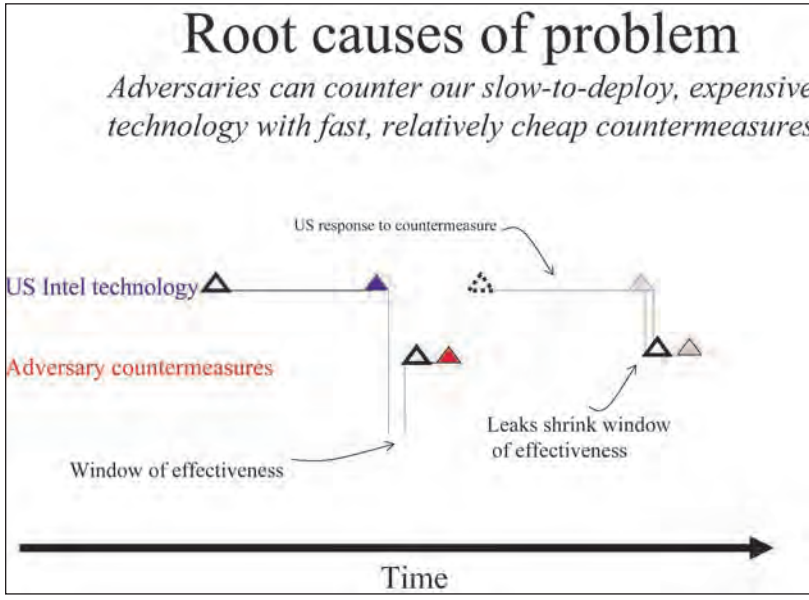

Figure 123. Root Causes of the Problem – Slow Versus Fast. *Source: Author.*

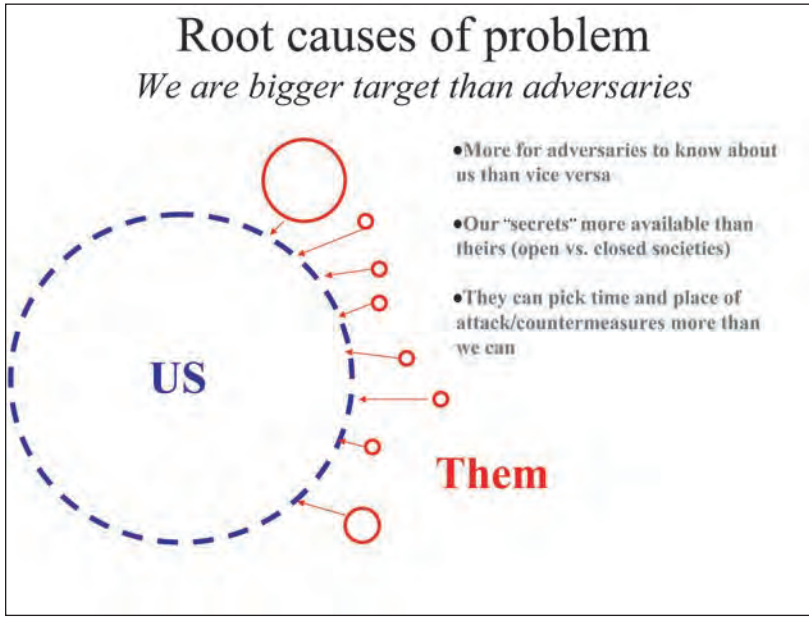

Figure 124. Root Causes of the Problem – Bigger Target. *Source: Author.*

ror and ask ourselves is have we peaked as a civilization, and are we on the down slope, because other people are getting it much faster.

When I ask audiences this very depressing question about what new innovations have happened, almost every time someone says IEDs, and they ain't ours.

So here's another aspect of the problem. There's a lot of them and few of us, and we have to organize against the best of all of them as if we have to go up against the all-star team.

So here we are. It's as if we have lethal mosquitoes trying to put lethal viruses inside of us, and we cannot turn on them. And a virus is a good analogy. It uses our own machinery against us, and that's what terrorists are doing. They used our technology, our airplanes, our money. And what have we got to become, other than this?

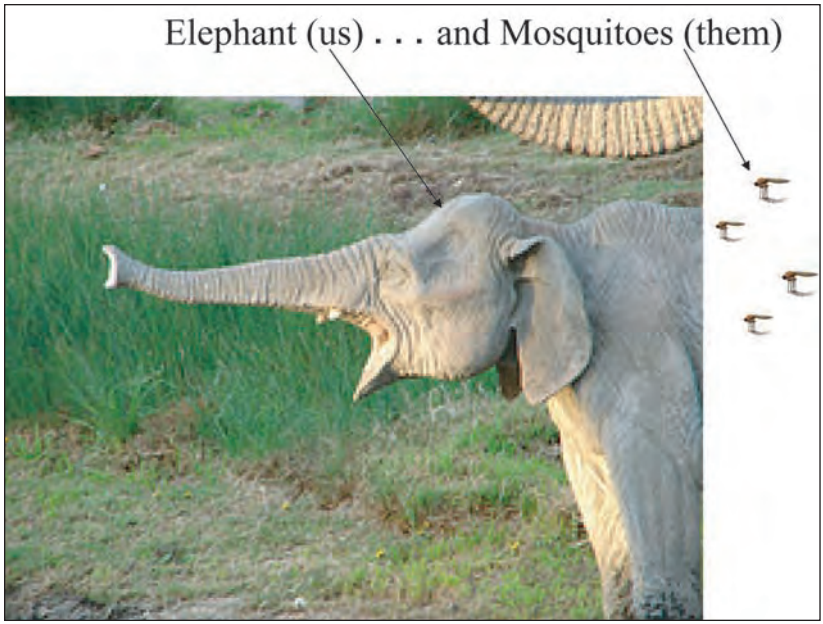

Figure 125. Bottom Line. *Source: Author.*

And before I leave the elephant, I want to point out as a behaviorist here an interesting paradigm called learned helplessness, and it has to do with elephants. If you take a baby elephant and tie a rope to its leg and a stake in the ground, what does it learn? It learns that it can't pull the stake out, but when it grows up to become an elephant this size, could it pull it out? But does it?

That's what's happened to us. We have learned helplessness. We are all so used to these decade-long programs, the slow pace of innovation, that we just don't think we can do any better. I think there are a bunch of you when I said we

ought to roll out innovations in ten weeks or ten months, you go, "Right. What is he smoking?" And you know what? That attitude, not to be critical, that's learned helplessness. I'm here to tell you we can do it.

How long did it take us to do the U2 from drawing board to first flight? Nine months, for the U2.

PARTICIPANT: It wasn't covered under the FAR (Federal Acquisition Regulation).

DR. HASELTINE: That's very true. And how long did it take to do Corona?

PARTICIPANT: And multiple failures.

DR. HASELTINE: Right, but you have to fail fast, as Tom Peters said. We fail slow. We aim low and miss low.

PARTICIPANT: We fear failure.

DR. HASELTINE: Well, that's right.

PARTICIPANT: We're risk adverse.

DR. HASELTINE: That's right, and that's the way to guarantee it. My point is this, I think probably a lot of you in this room have learned helplessness, and you know what we're here to say? We're here to say, "No. We can do it." And let me give you some examples.

I can't go into the details, because this forum is unclassified, but I went to Iraq in November of 2003, went back again two months later to see what we could do about IEDs, and two months later, we were putting a dent in that problem, because we figured out a way to use some existing technology that was already in theater.

So what I'm here to tell you is it can be done. It has been done, but we have to turn spot stories like that into more the rule rather than the exception. In short, we have to do the following.

We have to adopt three pillars of our strategy, and this is the overt agenda which Steve and I are here to infect you with—the mind virus. We want to be the good mosquito that infects you with this virus, and the virus has three strands, not two strands of DNA. The first one is speed. As a community, we must, must, must get much more agile than we are today.

Number two, the things we do have to surprise people. And number three, we have to do it as a team, and this is especially important with science and technology and especially important for this audience, because in science and technology, more than any other discipline, if you do not collaborate because everything's getting so specialized and so diverse, you do not succeed.

Science magazine did a survey of their own magazine and found that ten years ago the average number of authors was four, and now it's over ten. And that's not just because you can with the Internet, but because you must.

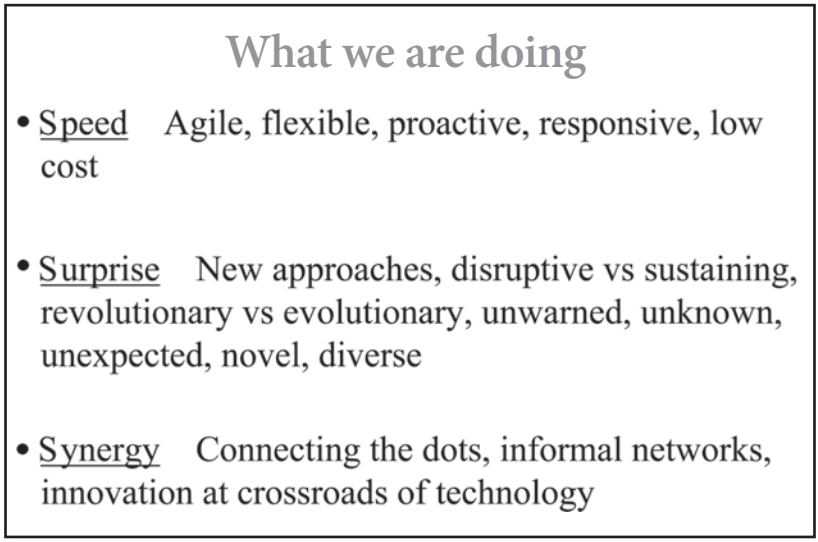

Figure 126. Speed, Surprise, Synergy. *Source: Author.*

Think of who you have to have on your team. The most important thing, of course, is a programmer, and I'm only half kidding about that. But you need a physicist, a chemist, a materials scientist, an x-ray crystallographer, a spillation, splattering, whatever you need, you know. You need all these different niche things, and so if you look at that and transpose it onto the Intelligence Community, if we really want to kick butt with technology, we've got to do it as a team, because that's in general the way that science is going.

And so this is our mantra: Speed, surprise, and synergy, and guess what? October, for the DNI, is S&T Month. We have succeeded in getting this kind of PR thing going, and so we are here to kind of kick it off.

PARTICIPANT: What does that mean?

DR. HASELTINE: Well, what it means is that leadership of DNI, including my boss, who kicked this off yesterday with a speech at the Wilson Center, although somehow his comments on the NIE got a little more play than the S&T material that he talked about, and that's kind of been baffling me all day—but the point is that he made a major policy speech, which we'd be delighted to get to any of you, in which he laid out essentially what we are just saying right here, that we don't need a band-aid to solve our problems with science and technology. We need major surgery, and we need it fast.

And he said it much more eloquently than I just did, but that was the essence of his point. And you're going to see hopefully other leaders at DNI throughout October make this point, and you're going to see public events and so forth.

But the point is that a huge portion of the entire intelligence budget goes to technology in one form or another, and I mean a really big chunk of it, and so this is not a small thing. This is a very big thing, and we have brought people around to that point of view, not that they necessarily needed a lot of persuading, and we're really excited about it.

And so here are the things that we're working on. I said speed, synergy, and surprise, and I'm just going to give you—you can see the main pillars that support those bubbles or whatever.

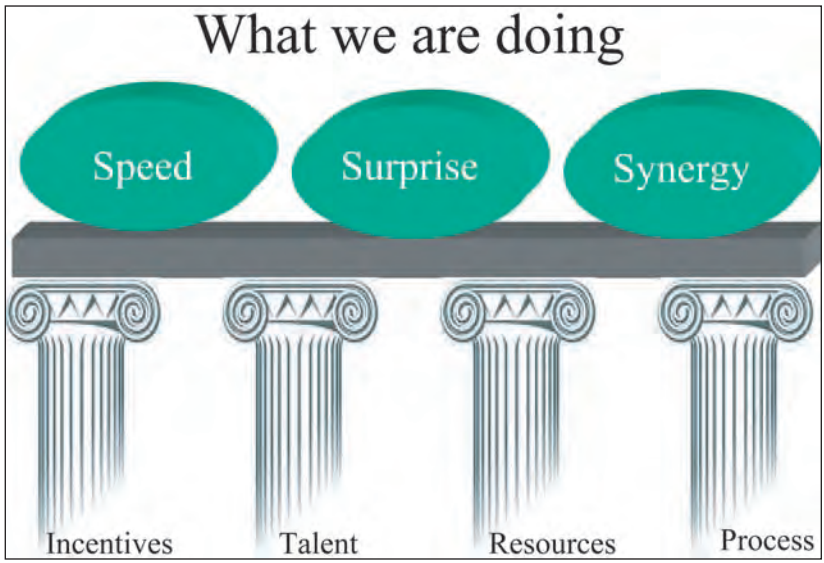

Figure 127. The Supporting Columns of Incentives, Talent, Resources and Process. *Source: Author.*

And I'm not going to go through everything here, except to point out that your DNI is on the case. We have got a major initiative against each of these things, and I want to pay particular attention to the talent piece. I think at the end of the day the synergy piece, getting different scientists to come and work together and get to know each other is in some ways the most important part of our job, and it seems a little bit counterintuitive when you think about it.

You say, "Well, wait a minute. Cooperation and committees do not normally equate to efficiency and speed. The more boxes you have to check, the more roots you have to bind, the slower you get." And I would argue the opposite, however. If you look at the history of any innovation, what you almost always find is it's much less about a what than a who.

HP (Hewlett-Packard) did this. They actually went back retroactively and looked at the big moneymakers and how did these things come about. How did ink-jet printing come about? How did laser printing come about? And

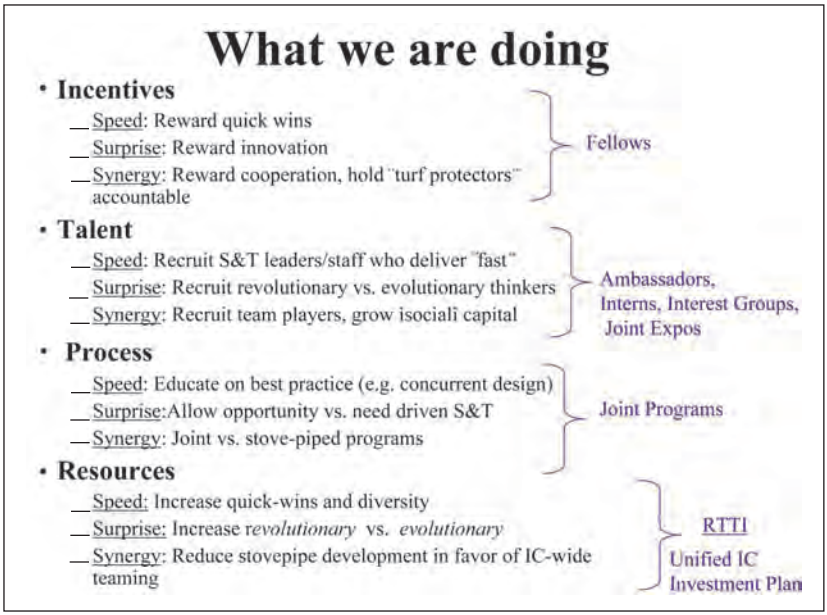

Figure 128. How the Columns and Speed, Surprise, and Synergy Connect. *Source: Author.*

what they found is Professor X knew Engineer Y, and they got together and said, "Gee, you know, we could put chocolate and peanut butter together and make a Reese's cup." And so this business of diversity—if you look at the whole history of science—big breakthroughs almost inevitably are preceded by an unusual fusion of diverse disciplines.

You know what Einstein spent most of his time doing before he hatched his general theory or relativity? He was trying to understand tensor calculus, an area of math that he didn't understand, but he knew if he didn't take that diverse piece of knowledge and marry it with his intuition about space time, that he would never get there.

And if you look at the discovery of DNA with x-ray crystallography and molecular biology and genetics all mixing together, and if you look at nanotechnology today, you'll see it over and over again. So cross-pollination is the key to rapid innovation, and it's also, I think, probably one of the more lasting things that we will accomplish.

Naturally, under the resources part, we're trying to get more money, and what would you expect the bureaucrat to say otherwise than that? But the key is we want to put resources on things that are not evolutionary but revolutionary, either revolutionarily fast or revolutionarily surprising.

So I want to leave you with a few images, because, again, as Alan Kay used to say, a word is worth one thousandth of a picture. So, you know, I don't mean to say that size is all bad. Now you could be one of two things in this

Figure 129. Vision of the Future. *Source: Author.*

picture. You could be the mosquito, or you could be the bat. Which one do you want to be? I'd rather be the bat. For one thing, the bat is bigger. So size, in the right amounts, is a good thing, but I think that we have to be more like a bat and less like an elephant, to mix a metaphor, and I don't know any learned helplessness parables about bats.

But there's another aspect, too, and Steve keeps reminding me of this. It is not important to just morph yourself from an elephant to a bat. What evolution teaches is that diversity wins. Go back to my point about the Permian extinction. If you look at it from the point of view of life on the planet, if really there's only one thing called life, and it takes a zillion different forms, then life's strategy for surviving is diversity. The fact that it had a few organisms that could survive a meteor strike is why we are sitting here breathing today.

And so it is not important just to solve it once, but you have to solve it again. And a frog is a different thing than a bat, but they both eat mosquitoes, and then the last one is my favorite. It's a chameleon. It can morph on the spot. I also wish I had a tongue like that. With that note, I'll take any questions you may have. Thank you very much.

PARTICIPANT: Excuse me. It's not like I'm disagreeing with you, but I sort of agree with everything you said but have a different perspective, and this is that we have all sorts of tools, and maybe technology enhancement is not the most important way to go. Maybe deploying the marvelous technology we have now and coming up with creative ways of tweaking our system so they're better able to deploy what we have.

Using your IED analogy, they didn't have to revolutionize anything. They had to look at what they had and come up with a creative way of applying it. Where is the investment for that, which is much less sexy, often, than the new revolutionary high-tech, expensive defense contracting investment?

DR. HASELTINE: Well, I think that there isn't an incentive to do it. I didn't dwell too much on the incentive part of those pillars. I think that's the heart of the issue. If we're getting slowness, we're rewarding slowness. If we're not getting speed, we're punishing speed. It's pretty simple when you get right down to it. I don't think anyone could argue with that.

We have to come up with a different reward structure, and I would point out that there are two elements to a reward structure. There is the obvious one, which is you get budget and promotion and glory for having a $10 billion program, and if it turns into a $15 billion program because you slipped five words, then you get more promotion and more glory. So our reward system is all screwed up.

But there's the intrinsic reward. I've described extrinsic rewards. Certain people are wired to just go do it, roll up their sleeves, get out there, and go do it. And we want more of those and less of people who are happy taking

15 years to do something that's 15 percent better than it was 15 years before. And so I think it's mainly a recruiting and casting issue, and somehow we have to recruit and retain into the Intelligence Community technologists, scientists, and innovators who want to and are able to get things done fast.

And by the way, since you can't get anything put in place for the mission in less than five to ten years, why would you stick around if you were someone who was impatient to see results, which is why I say we are really punishing speed. And so I don't argue at all, and I think that what Steve and I are trying to do with the rapid technology transition initiative is to reward speed.

The slow part is going to come next week when we review people's budgets. Maybe we're going to be gentle. But I think you understand where we're coming from, that you have to work both sides of the equation. You have to reward what you want, and then you have to kind of discourage, let us say, what you don't want.

And I'm not so naive as to think this is going to be easy, but what we're doing is—just to dwell on it a little more, one of the things we did with the fellows program that you saw up there is we picked the very best brains, who are showing that they could get stuff done fairly quickly as a team, and that's where we put our money.

We gave them each $200,000 to do with for research whatever they want, no strings attached, the only question being just hang out with the other fellows four times a year. And it turns out those people turn out to be pretty fast if you give them money and empower them and remove obstacles. So again, it's an example of rewarding the behavior that we want to see.

PARTICIPANT: I have two quick questions. First, are you are looking at making the requirements that people are trying to solve small? Because, if you notice, there's generally, not always, but especially for land animals, there's a direct relationship. The bigger they get, the slower they get. You need to be small to be fast, especially to be fast and agile where you can turn quickly, and the turning quickly usually comes when you realize the direction you're going in is going to lead you into somebody's mouth or a brick wall.

And that leads to the second point, which is rewarding learning from failures. We have to incentivize success, and we have to incentivize speed, but I think there's also a need to come up with a way to incentivize good failure, failure that you can learn from. Obviously, catastrophic failure isn't too good.

DR. HASELTINE: Well, first of all, I agree with almost everything you said, maybe 100 percent, depending on how you intended it. We do believe that small equals fast, but small solution does not necessarily mean small impact. After all, we are after big impact, and sometimes you get big impact by being faster than the enemy thinks you are in a small way, and sometimes you get it by having some revolutionary big secret weapon like a nuclear bomb.

There isn't one answer, but we have to start somewhere, and the first thing we want to do is break the Community of the habit of these huge, huge, long programs, and so—by the way, sometimes you need huge, long, revolutionary programs. It isn't that we don't need any of them. We need far fewer of them and a lot more diverse small things. Some of them may not have the biggest impact, but it isn't a given that because it's a small technical solution it isn't a big impact, and wherever we can do that, we will do that.

PARTICIPANT: I wanted to make a contrast and ask you your view of relative effectiveness: In our system in the United States we have private corporations who are responsible to the shareholders and a government structure that protects the private sector interests from the government and protects the government from undue influence by the private sector. And the motivation, the responsibility of the corporations is to the shareholders, and responsibility to the government is essentially obeying the laws.

In the Russian Federation system, for example, and China, the state corporations operate, and the decision of the government based on its comprehensive plans on its priorities structures the corporations for the national interest and can purchase corporations from the United States in the interest of the government and can purchase technology. In the United States, on the other hand, corporations depend on government contracts and have to take the bottom line into consideration with regard to purchases.

If you look on the Internet, the Kremlin website, personal website of President Putin, one of his top priorities stated is to acquire nanotechnology assets through global sources, and to develop it within the country. What is your view of the relative ease and speed with which each side can achieve its technology objectives given the difference in the system?

DR. HASELTINE: Well, I think they can be a lot faster than us, you know, and they have been. They don't have some of the same constraints we do. They are big bureaucracies, and that is the law of nature, I think, that slows you down. But your point is a good one. I mean, other people don't have all the qualms we do about doing what you have to do to get what you need to succeed.

But I do want to go back to first principles. We do not have to give up who we are as a people or our values. All we have to do is go back to our old values. What was it that enabled us to put a U2 in the air in nine months? That was not so long ago. Almost all of us were alive when that happened. We know how to do it. We just have to remember how we did it, you know.

And so I think that we were a democratic people then. We had a nation of laws and a government of laws back then, and we did it. The Intelligence Community has special authorities because of the business we're in. We can just

go buy stuff, and we can do it fairly, without corruption, and we can do it above board, but we can do it much more quickly than we do it.

And, like I say, I think to some degree we've learned helplessness, and we have clear proof that it can be done. Heck, in World War I, it was 90 days from drawing board to first flight on some of the aircraft, right?

PARTICIPANT: And money back then was plentiful.

DR. HASELTINE: Yes, it can be done. It can be. It absolutely can be done, and it is being done. You know, the good news is that in an enterprise as big as we are, there's a tremendous amount of talent, and I'm here to tell you that I am very encouraged by some of these programs that we have. It's just an incredible wealth of talent, and there are success stories happening all the day.

But it's an archipelago of isolated things, and it's our job, Steve's and my job, to take this archipelago, create causeways between it, and turn it into a continent, if you will, to really make it a significant part of our culture, as it was at one time.

PARTICIPANT: I just have one question regarding that, and that is are you set up now so that you can do the rewarding and punishing of performance organizationally with all these different entities?

DR. HASELTINE: I know the punishing word is going to come back to hurt me. Why don't you remember just that blue light in *Men in Black*, you know, just discourage. We're getting there. We're getting there. You know, just the fact that we're here talking to you, the fact that my boss, Ambassador Negroponte, buys into what we're doing enough so that he'd get up in front of the Wilson Center and make a speech, and tomorrow he's going to make a speech in the House and echo a lot of the themes that you've heard here today.

We are gathering support at a rapid level, because our message is one that I think resonates with people. We all look around at what frustrates us in our day-to-day jobs, and we want better solutions, and we don't want to wait ten years for them. And we all recognize that perhaps investments that we've made in big technology programs have been somewhat disappointing across the last several years.

So I think we're at a learning moment with our government. I think the American people, the Congress, have an appetite for people with innovative ideas and rapidly adapting to a very resourceful and agile adversary. And so I'm overall optimistic, but, you know, clearly we have a few challenges to surmount, but Steve, what do you think? Are we going to get there? We'll get there.

PARTICIPANT: I wanted to address your aspect of diversity and possibly suggest that what is changed in America from 1940 until today is the internationalization of the process, where at one time we had a good grasp on immigration and integration of those immigrants, where today we have brain drain.

Instead of taking from the international community where they're going much faster than us, we are actually doing the opposite. They're coming to us and taking the best of what we have and taking it back to their countries.

DR. HASELTINE: Well, I don't think the data completely support that at this point. We still lead the world as you know, I think our top universities, the top ten in the world, nine are American universities. Still people who come here want to stay here. We still invest more in R&D per capita than anybody.

So there are still some very positive, healthy things going on. I don't think we're quite to that point, although, true, some of our technology has leaked out, but it works both ways, too. You know, we're benefitting from others. Like in certain areas, we can only get certain pieces of equipment in China, but we do get it. So it isn't clear to me that what you said has completely happened, but the trend line is not good.

If you read *Rising Above the Gathering Storm*, ultimately, if trends continue, then I think the scenario you painted is going to happen. But you know what? In the intelligence business, we're supposed to get out ahead of things before they happen, and that's why we're here today.

Mr. Hiponia thanks Dr. Haseltine for his participation.

PANEL DISCUSSION

PANEL DISCUSSION
Technologists, Operators, Stategists: Developing and Using Integrated Solutions

Discussants: (Shown from left to right in the photo)
Lt Col Timothy Murphy, JMIC National Reconnaissance Office Visiting Chair; Mr. Michael J. Cleary, Directorate for MASINT and Technical Collection, DIA; Mr. Andrew W. Reynolds, Deputy and Chief of Staff, Office of Science and Technology Advisor to the Secretary of State; Mr. Marc Viola, JMIC Faculty

MR. HIPONIA: HOW DOES S&T fit into the mission of the intelligence professional? That's one of the questions that our panel this afternoon will be trying to answer.

We have on this panel an operator, a technologist, and a strategist or analyst, and they'll be discussing how to develop and use integrated technology solutions to solve intelligence problems. Our panel moderator is Mr. Marc Viola, who is on the Joint Military Intelligence College faculty. Representing the operator viewpoint is Mr Mike Cleary from the Defense Intelligence Agency. Representing the technologist's perspective is Lieutenant Colonel Tim Murphy, Ph.D., JMIC faculty, and National Reconnaissance Office Visiting Chair. And finally, representing the strategist and analyst perspective is Mr. Andrew Reynolds, Deputy and Chief of Staff, Office of Science and Technology Advisor to the Secretary of State.

MR. VIOLA: On behalf of the College, I'd like to thank everyone for coming today. This is a great opportunity to bring people together in a pursuit that often gets overlooked sometimes by the Intelligence Community. We just assume that science and technology is going to work.

As was mentioned, I'm a visiting guest faculty lecturer. I actually was a faculty member for a while, and I went back out into the intel community. I spent ten-plus years in the Air Force, and I did a series of different kinds of intelligence specialities, most of which were centered around MASINT, measurement and signatures intelligence.

LT. COL. MURPHY: I'm going to focus on the topic, rather than myself. I think I'm fascinating. My wife and kids think I'm fascinating, too, but I'm sure you folks want to hear some ideas about the place of science and technology in intelligence. And first of all, I want to say I'm very appreciative to be able to be here.

This is a topic that's been on my mind for a number of years when I was in the white world, when I went to the collateral world, and then particularly when I was in the compartmented world, so I think it's a very important issue. It's a magazine front cover problem and a critical issue for this nation to come to grips with.

About a hundred years ago, I think, when people wanted to build a building, they built it by themselves. They'd go out and build a barn, or they'd build a house, or they'd build a coop, whatever they needed, and they could design it and pick out the materials and put it together on their own. Certainly 100 years ago people used to build their own machines. For example, they'd build car engines from scratch. They'd make the bits and pieces themselves.

We got into the sixties, and the buildings that we were building were skyscrapers, and the machines we were building were spacecraft. And human beings found that they needed some help, that they couldn't do it on their own anymore, and so they began to take advantage of computers, which allowed them to build things without actually building them, to test alternative designs.

And they were willing to cede some of the work to technology. A lot of people in science and technology are, I won't say proud of themselves, but—well, no— I will say it. They're proud of themselves, but they're willing to see that the human brain has certain limitations, and so they relied on computers to help them keep track of all the inputs and outputs, keep track of all the variables.

Now we're faced with a problem that's easily as complex. It's easily as complex as building a skyscraper or putting a satellite system together. I mean things like looking for a biolab or indications of a terrorist cell. And while you would all think it would be ludicrous for me to say I'm going to go and build a skyscraper all by myself, it seems to be, in the Intelligence Community, we're saying what we need to focus on is the individual analyst and how he can address these problems.

I think humans need help, and I think technology is a tool. As we've heard from just about every speaker, S&T is a part of a solution. So, I don't think even Dr. Yonas would disagree that just because an organization is put together

and someone is in charge that there is a problem, that he would want to try and dial chaos at exactly the right amplitude and phase to cancel chaos.

There has to be someone in charge. There has to be somebody that puts a strategy together, and we must have someone that stands back and makes sure that everyone working a problem understands that it's not a tame problem. And so I think that the science of intelligence needs to be addressed. The strategies need to be addressed where you put all the bits and pieces together, and that's something that we should look at in the near future.

Lt Col Tim Murphy emphasizes a point.

MR. CLEARY: My name is Mike Cleary. Thanks for having me here today. Let me talk about developing and using integrated solutions in terms of technology, let me talk about that from my vantage point and really what that means to me here, and then in the future.

The word integrated in that strategy doesn't mean to me integrated technology, integrated circuit boards. It doesn't mean anything like that. It means integrated in terms of who comprises your team, who is on your team that's developing the strategy. That's integrated.

So you have a panel here that has a technologist, a strategist, an operator, a moderator, planners. Who is on your team? Operations? That's a must. A collection planner? That's a must. An analyst? That's a must, and an engineer or a technologist in terms of doing collection operations.

But those aren't stove piped people. When they're on the team, they ought to be able to interact and also learn and fill in for each other. The engineer ought to be able to do some basic analysis and understand what that is so he has a good feel for what that analyst's job is on the team.

The collections planner had better know what the operations requirement is, and that better be translated to everybody that's on the team, because the fundamental underpinning of the success of technology going into the field is, did everybody on the team understand the requirement from the get-go, because if they didn't have that, then you lurch, and you veer, and it takes time and money. So those components are critical in terms of integrated solutions, and that's the way we look at it, and that's the way we practice it.

I walked in at the very end of the last presentation, and I heard somebody say, "Hey, it's working really well at the tactical level" in terms of S&T and intelligence, and I would second that, and I would even go so far as to say it's working well at the operational level, as well. We have a long way to go, but it's working well.

Let's go back to the requirement, because, I can't foot stomp enough about everybody that's on the team understanding the requirement. I mean, the objective or requirement is going to be the fundamental thing that everybody's got to do. Whether you're in operations, collections, analysis, engineering, everybody's got to do critical thinking on that.

That is the key piece up front that is going to pay you dividends down the road, the way it is for us, because there is nothing easy about fielding technology and getting it out there and using it. There really isn't. The team concept, crossing the barriers at the lowest levels, is what's really driving this and making it happen.

MR. REYNOLDS: Well, the problem in having a panel in the afternoon after so many sage people speak through the day is that there isn't much to say, but I took upon myself to try to distill from our distinguished speakers who started this seminar some of the things that really resonate with respect to the strategic viewpoint at the State Department as a user of intelligence as much as anything. But remember, we do have a very distinguished bureau of intelligence and research, a small member of the IC, but a well respected one.

Let me just reiterate. This is a session about the technologists, the operators, and the strategists and how we develop or use integrated solutions. One thing about this bully pulpit that I represent, the Office of the Science and Technology Advisor to the Secretary of State, I should tell you

is that our senior scientist is a physical chemist, Dr. George Atkinson, from the University of Arizona, and he has been with us now actually five years, because he began as an American Institute of Physics professional fellow, which was emblematic of what we have been trying to do as an office in our mission to build greater capacity in the State Department to follow science, technology, and I would add engineering.

I think the general public tends to see technology as a given. I tend to say it's mighty different when you're talking to engineers, per se, because engineers design, build, operate, maintain infrastructure, and we wouldn't be sitting here without the engineers.

The second thing I'd like to say is that State is a unique culture. It's a culture of three different types of people, all on different career paths, if you will, because there are about 12,000 Foreign Service officers who are recruited and hired and promoted and retired under an entirely different system than the civil service, of which I am a member. We have about 8,000 members of civil service in the State Department. But the largest single fraction of our personnel is about 40,000 people overseas, the Foreign Service nationals, who are in essence the civil service for us in our foreign embassies.

So by extension, the greatest portion of the State Department is overseas, and, in fact, if you look at the State Department organization, it's the strong bifurcation of two principle drivers of how we do foreign policy, the regional bureaus, Western Hemispheric Affairs, African Affairs, Near East Asia, et cetera, and functional bureaus, the people that follow arms control nonproliferation, the people who follow economics, business, agricultural affairs, the people that follow science, technology, human rights, democracy, et cetera.

So those two dynamics are very much at work in the very difficult practice we have of establishing strategic priorities, foreign policy, and in being stimulant and users of intelligence. And in the science and technology moniker for which this workshop is designed, it's even a more difficult proposition over time, because you will find there isn't a large cadre of scientifically literate people in the Foreign Service. There's a larger fraction in the civil service and a good number in our Foreign Service national cadre overseas.

But we like to say in our office that national security is built on three pillars: intelligence, diplomacy, and war fighting. And we like to say that the brick and the mortar of the three pillars are science and technology. It's a common nomenclature through which we can identify our common interests, through which we can get the strategic and tactical responsibilities and tasking, and it's also a way of communicating.

And for the State Department, a culture which is really 24/7, like the armed forces, like the Intelligence Community, but really fixed on three-, five-, and ten-minute problems. And if you're lucky, three, five, and ten hours, three,

five, and ten days, maybe three, five, and ten weeks. But, three five and ten months, forget it. So when we're talking about science and technology and engineering and long-term strategic thinking over three, five, and ten years, it's very, very difficult to impose or to impress upon our culture in the State Department in general that these are important.

If I may just take a few more minutes, because as we go through questions and answers I'll have a chance to perhaps reflect on a couple of particular points I wanted to make today, but may I go to Professor Oettinger first because through his remarks and those that followed, there are several themes I would like you to continue to think about, particularly because he asked that you begin by thinking about two particular lenses through which to evaluate what you were hearing today.

The notion of ideal technologies, and who applies them first, that's the great race and where the advantage for the United States has to be fostered and continued. And the collaboration with multiple stakeholders, very important, and I was elated to hear him reinforce HUMINT, human intelligence, new tools, which were never more important than today, particularly considering our adversaries.

Rita Colwell reinforced these same themes but went further. Multidisciplinary international approaches and basic research and applied technology development are critical. And something that we advocate as the science and technology advisor within the State Department culture, we have to be proactive rather than reactive all the time.

We are constantly reacting to the three, five, and ten-minute fires on the desk, and we are trying through the science and technology and engineering lenses to say, "Let's look at three, five, and ten years once in a while and see where basic research is taking us, and applied technology may, in fact, be manifest in both good and evil ways, especially in a world where science and technology and engineering are so ubiquitous now, as Rita and others pointed out.

Mr. Pappas said something very interesting. "Collection and analytical capabilities do not scale." He also said that we need revolutionary and not evolutionary multidisciplinary approaches. Boy, that's the hardest thing that we do. Dr Atkinson, our advisor, is a revolutionary guy. It frustrates him every day, and it becomes my frustration when I say, "George, we're in an evolutionary culture. You've got to be patient." He's not patient.

Also, Mr. Pappas said that OSINT should be used to target classified assets. Thank you very much for that statement, because it is through the unclassified basic and applied research phenomenology and community collaboration, the largest single source of S&T information, open source information, that we can begin to really discern, I think, better indicators for strategic

warning and tactical warning. It just takes a little more hard work and some institutional revolution, as you said.

Mr. Andrew Reynolds takes in a query from the audience.

The State Department's pretty proud of its linguistic capabilities. I think the armed forces do very well, as well, but we have launched in January, with President Bush's blessing, Secretary Rice, Secretary Spellings overseeing, two important milestones, a conference on international education, a summit of 120 university professors and provosts, to ask of them that they continue to improve on curricula, including teaching wicked engineers wicked things, but above all making American students more global.

And that means also an international security language initiative, which says, "Go out and study hard languages." We need Mandarin speakers, Japanese speakers, Arabic speakers, Hindi speakers, Farsi speakers as never before and, I will add, wicked engineers who are also competent in their languages.

The international education summit also asked the leadership of our American universities to work hard to regain the high ground that we had as the major attraction, global attraction, as education institutions. Bring back the teeming masses that so nurtured us after World War II and continue to export through those young people the meritocracy and the peer review and the democratic principles of science and engineering, which are so important to all that we are trying to do in transformation of diplomacy.

It seems like transformational is everything now. Transformational military capabilities, transformational intelligence, and by God, Ms. Rice, Dr. Rice, wasn't going to let it get away from us. We're in transformational diplomacy.

Mr. Thompson also mentioned analysis to keep up with collection. That is that holistic approach, which Gerry Yonas also mentioned. You cannot do these linearly. Strategic warning needs long-term views. Core values of science and creative peer reviewed, as I just mentioned. Open source, all source, with OSINT as initial indicator of change or activity, resonating on Mr. Pappas' point.

And finally, my good friend Gerry Yonas, who said, as Pogo said, if people in this room remember who Pogo was, "We have met the enemy, and he is us," and I'm old enough to remember that cartoon strip. Also I thought very salient his point about a general objective of sustainable dynamic stability through a creative spiral process of multi disciplinary approaches.

The United States does not have a monopoly on science and engineering. If we ever did, we certainly do not now. We have to go outside to continue to find that excellence.

I think my last point before inviting questions, would be that continuing education, as Gerry said, is vital, and my 88-year-old mother-in-law, a reference librarian by career, is my mentor for that, because for her, learning is a lifelong process. I think it should be for all of us.

MR. VIOLA: All right. Without further ado, what I'm going to do is I'm going to pass out your questions to our panel members. Now you've categorized the addressee of the question up top, so what we're going to do is we're going to give everyone an opportunity to go through the questions that they have and then begin responding. And once again, please don't limit this to people here talking. We'd like to know what your opinion is and really engage in dialogue. Can we start at the end there, Tim?

LT. COL. MURPHY: Sure. "What is being done to improve the dissemination of science and technology intelligence to non-government labs and industry development?"

I was out at Argonne the week before last with the National Consortium of MASINT Researchers, and they were briefing their programs, and I

think that Dr. Bythrow and that group have done a great job of picking projects which have a quick transition path. But one of the themes that repeatedly came up from the technologists was, "Tell us how you're going to use this."

It was particularly in the unclassified sections one would hear a university briefer brief these great ideas, and the folks that knew something about the Intelligence Community would sit there and say, "Well, how are you going to make that small enough so somebody can get it where it will do you some good?"

In the three years that I developed missions at the NRO, it was a repeated theme that industry was smart about science and technology, and they could make very good guesses about how things would be used, but when we asked them to tell us how another country would use a science and technology, their hands would go up in surrender.

So we're asking industry, and we're asking academia, and we're asking the labs to come up with solutions to problems when they don't understand the problems. They don't know how they would apply their concepts. They don't know what frequencies are being used or the CONOPS that are being used, and yet we're spending lots of money to ask them to develop solutions.

So I think this is a very large problem, and the only solution is to somehow incorporate industry into our conversations, perhaps even here at the school, at JMIC. I know that the Air Force Institute of Technology brings people from industry in, but one of JMIC's really treasured attributes is that we bring people from different government organizations, State Department, FBI, from the Navy, the Coast Guard, the Air Force, the Army—who shouldn't I forget, sir?

PARTICIPANT: Twenty others.

LT. COL. MURPHY: Twenty others, and we sit them all in a room, and we sit and discuss things that we know and bring personal knowledge to bear. We have in this school a tremendous access to classified information that is just everyday stuff that we go and look at, and we answer questions. Once again, the guys in industry don't have that, don't have that capability or access.

So I think it should be in all of government, in all government agencies and where everybody would have opportunities, particularly, you know, for the national intelligence university, to look for ways to incorporate S&T people, and I think that they would be more than willing to embrace dissemination of this special information.

MR. VIOLA: Does anybody have any comments on that?

PARTICIPANT: I just wanted to say that there is a congressionally mandated program called the Technology Transfer Program, and every federal lab that has 200 or more scientists, mathematicians, or engineers must have an ORTA or, Director of Office of Research and Technology Applications. There is

a congressional mandate that we must transfer the technology to industry, universities, state and local governments, and other federal laboratories.

I know that I just came from a Mid-Atlantic conference where the ORTA was there from U.S. Joint Forces Command. There was an ORTA there from NIH, the U.S. Agricultural Department. All over there are ORTAs, and there is technology out there that's begging your attention, industry, and university, and state and local governments.

Also, if you know about the SBIR—we call it SBIR, but it's the Small Business Innovative Research Program. DoD has one. Navy has one, and they ask for people to present their proposal on mission hard topics for which you can get funding. Sometimes universities go and do this, and they spin off a company that goes on and gets a second one, and then possibly even a larger contract that answers mission issues and problems.

So it's out there. Just go to a federal laboratory consortium. That's the mandated organization that's supposed to pull all the federal labs together, federal laboratory consortium, but there is so much legislation out there for tech transfer.

And you say, "Well, how can NSA do that? You have all that classified stuff." I get all my technology first reviewed. You only get access to the classified releasable technology, but if your company—and we work with big companies as well as small companies—but if you have your clearances and your facility clearances you can get something called CREDAs, cooperative research and development agreements, and those are partnerships. Those are research partnerships that you can work together.

NSA does not charge any money for our CREDAs. A lot of other federal laboratories do, but we don't. We come together, and it's almost like a contract, but it's a statement of work that says, "This is what we want to do." And you come together, either in that industry's facility, that university's facility, or the federal lab's facility. So it is out there. I would say, do some Googling, and go and try to find that.

PARTICIPANT: One of the things that I keep hearing, and I've been doing advanced R&D for the last six years, is that there's all sorts of things going on, and nobody knows about it, and that's part of the problem.

We're probably the worst at sharing information on what's going on in S&T, and I really think it would be most helpful if we would take advantage of some of these new technologies like wiki technology, the equivalent of a Wikipedia, or blog, both at the unclassified level. We could do password protected at the unclassified level, all the way up to Intelink, to begin to share what's going on, because there is so much happening. It's not just about what's congressionally mandated, but how do we find out about a small group that are primarily in the program. You go to a conference like this. People find out about them,

and nobody else knows, and that's the problem. Somehow we need to come together, and we need to make this information available.

The nice thing about something like Intellipedia or the Wikipedia version is that there's the ability to discuss things, to share ideas, and we need to start that. The Defense Technical Information Center (DTIC) is wonderful. I mean, DTIC's wonderful for sharing, but it's like a read-only kind of thing.

Now perhaps DTIC would be the logical place on the unclassified side, but somehow coming out of this, it would really be nice if somebody would take an initiative, and I know the panel's not the place, but to say, "Let's set up something where we can begin to share this information at each of the different levels."

MR. VIOLA: I think that's a very interesting point that you raised. If we were in a different forum, I would be interested in the demographics of this question, and before I go any further, I am a MASINTer, but I think of myself more as a techno-anthropologist, because I really think that it has a lot more to do with people than not.

If we were to ask people, if we were to survey the Intelligence Community and ask them, "how many people in the Intelligence Community know what Wikipedia is or have ever been on a blog?" I would expect high numbers here in the S&T world, or representatives of the S&T world, but I think a lot of people might not be as knowledgeable. We are our own worst enemies. How much is it that we are just simply not looking because we're drowning in what we're doing on a daily basis?

PARTICIPANT: If nothing else, go to the University of Michigan's collaboratory project, which is funded by the NSF, and talk to them, because their whole funding, their whole project, is about how do people collaborate. How do we get work done on a daily basis? They're putting out some amazing lessons learned.

MR. VIOLA: It's its own science. I agree with you 100%.

PARTICIPANT: I submitted the original question. I think there's a point that needs to be brought up. We talk about intel support to the war fighters. The intel community needs to think about intel support for the R&D and S&T communities. I'll give you some examples. I'm with Johns Hopkins Applied Physics Laboratory. My office is responsible for funneling intel to the R&D projects within the laboratory.

We did a study in the late eighties. We were getting approximately 800 acquisition intelligence documents a year into the laboratory to support our projects. Currently on classified systems we have less access. In an IT-enabled environment, we have less access to materials to support R&D and support systems development than we did 20 years ago.

For another example, the Improvised Explosive Device (IED) program, when the Joint IED Defeat Organization (JIEDDO) came on line, the director of O&R stated that this was "a Manhattan Project to develop counter-IED technologies." For us to get access to the intel on IEDs took us approximately 90 days with the intervention of the seniorArmy Intelligence leadership before we could get access to websites, to get intel disseminated to the people who were developing the technologies to counter the problem. I would suggest that you have an intel dissemination problem, among other things.

LT. COL. MURPHY: Yes, let me make one comment about that. When General Hayden was here, he made it pretty clear that we need to review how we classify information and how we do access, and he brought it up a number of times, so I'm hopeful that that's something in the near future that will help us get over some of those hurdles.

MR. CLEARY: The question here is that many national and DoD labs are customer funded, and they seem to be drifting from their charters to do basic and applied research and having more folks do rapid technology development. The question is, "Is this a good idea, or are they sacrificing 6.1, 6.2 research to pursue target technologies du jour?"

Well, you've outlined the issue, and the best way for me to respond to that is rapid technology development is what's required right now for what we're doing. Is it sacrificing 6.1 and 6.2? I don't know if I can answer that. Do we need the 6.1 and 6.2? I'll go back to the Long War. You betcha.

So I don't have a solution for you. I see what you're saying, and I've seen it myself, but it's really difficult right now where we are with the war on terrorism to get the most out of rapid technology development.

LT. COL. MURPHY: I'd like to comment on that, having worked in the lab for a number of years. You have to put some money aside to let folks have fun, but I don't see any reason why some of even your basic research can't be focused in a specific direction. We went through an exercise that Dr. Yonas helped to organize out at an off-site, and what we were asked to do was prioritize some of the things that we need to be working on in 20 years, and I think you can do that.

On the other hand, if you work with the CIA, and they have people that they're trying to help today, you do have to get the money out to them. But it has to be a mixture of the two, and as time goes by, you'll swing in one direction or the other, but I think that that's pretty normal.

PARTICIPANT: I wanted to make a comment going back to what we were talking about, and also it goes back to what some of the speakers were talking about this morning. I've worked as a contractor out in industry for about 25 years for companies working for different parts of the Intelligence Community.

I have seen that the flow of data, especially intel support to acquisition, but also looking even at the R&D type documentation on future technologies and stuff, the flow has greatly diminished. I was working part of that time as a reservist, and I had access to all the systems, the data is out there, but it's very much more tied into the government, and it's very hard for most contractors to get regular access to these systems, to be able to, on a regular basis, see what's going on, see what the questions are, see what new things are coming out, to be able to come out with unsolicited white papers, to come out with Advanced Concept Technology Demonstration (ACTD) proposals and so forth.

So I just want to amplify that there is a dissemination problem, because the IT revolution hasn't crossed the wall from the government side to the contractor side.

MR. REYNOLDS: I'm going to try to answer a pair, because I think they're closely associated.

"How does the IC avoid fixation on a single type of threat or adversary when the world is complex, and the U.S. faces commercial and economic rivals, political and military powers competing for regional dominance, and simple tribal and barbarism threats to all complex civilizations?"

And this one, which I would like to try to pair with it, "How important is the development and maintenance of a community technology forecast effort? Do we really understand the future threats and opportunities?"

First of all, as a process, I would say it's important to understand that the State Department is a strategic user but also a tactical user of intelligence, because we have refugee issues. We have tsunamis. We are part of an international relief effort. If we go to ground in places under duress, we use tactical information all the time.

But we have an interagency process where we are together as a community talking about the imperatives, what are the issues at or over the horizon or closer in the emergencies that have hit us right in the face, and we get particular taskings to address those issues. So in that way, you sort out these various factors, political, military, economic, natural disasters, whatever it may be.

The more difficult one is moving to the asymmetric world of non-state actors, which is what we're about here as a major sub-theme of this conference. And we also have in the State Department a self-generated capability I alluded to, which is the Intelligence and Research Bureau, which is the finest of its type, particularly since it's small, using all source intelligence.

It is vital to maintain a capability for science and technology forecasting. If I may do a little retrospective on history, the National Intelligence Council had two seminal reports in 2000 and 2002, "Global Trends 2015," and the second one was the sequel to that, called "Mapping the Global Future 2020," which moved out five more years.

In those two reports, they spoke of key drivers for globalization or globalization as a key driver, for future relations, future world activities, and the development of economic, social, cultural, environmental events. And science and technology were featured, particularly the three big ones, the NIBTECH, to quote Gerry Yonas, for nanoinformation and biotechnologies and the synergies and intersections of the three.

The NRC, the National Research Council, also had a report, which gave us the breath of life as an office with a mission in the State Department. The National Research Council studied how science, technology, and health were underlying foreign policy of the 21st Century. They were asked this, because the State Department has lobotomized its capability beginning about 1985, and through gradual attrition and a cruel intersection of several factors was watching the graying of its capabilities or the outright elimination of positions overseas and in Washington, that were following science and technology.

And what the National Research Council panel, led by Robert Frost of Harvard University, concluded after 24 months was that 13 of 16 strategic objectives in U.S. foreign policy were underlaid or otherwise informed by science, technology, and health. To wit, "get work, get to business, get back to the task at hand, Madeleine Albright," at the time. You've got to rebuild a capability and stand up an S&T advisor to help you do it.

But I would like to go with a real clear retrospective to the Hart Rudman Report of 1998 for two reasons. It not only spoke to the same themes of the critical value of science and technology, but it also said that the single greatest threat to the American homeland was a weapon of mass destruction in the hands of a terrorist, a pressing thing. And it spoke to the need for a Department of Homeland Security, so it was forecasting, if I may say so, in retrospect, by the nature of such report. So yes, it is vital that we continue this effort.

My first boss when I was with the Department of Energy was a distinguished statistician from Stanford University. His name was Lincoln Moses, and I'm sure he's long gone now, because he was quite elderly at the time. He looked a little bit like Brother Yonas over there, except he was much stouter. He played an excellent Santa Claus. But the first annual report to Congress by the Energy Information Administration where I worked, he put in the foreword one phrase, "There are no facts, F-A-C-T-S, about the future," and so I say that to you.

Yes, it's vital to continue forecasting, but we're only using the crystal ball, but we can do rather well if we look at trends, and we keep our eye on the ball, and in our field, basic research is slow developing. You do need serendipitous funding for basic research. You do need the exploration of the unknown, and applied technology is taking us, and we know by experience how fast we bring things to market.

What we're seeing more than ever is this rapid evolution through nano, bio, and info, and the intersection of revolutionary new applied product much faster than we thought. But I think the big challenge in the forecasting world, and using S&T as drivers, is the ubiquitous S&T that we are experiencing in the world at large and the deluge of data, which is overwhelming the collector, and really that seminal problem in intelligence of separating signal from noise. And as we evolve, perhaps in the rest of this conversation, I can make a few other comments to that effect. That's how I would answer your question.

LT. COL. MURPHY: I'd like to add a comment, and I think Andy hit on something that I've come across repeatedly, and it's how do we filter all the data that we collect. How do we do that? And if it isn't by having a logical, dedicated approach to understanding a problem and bringing in information from economists and the operators and the people who know the culture and the history and the politics and there has to be some way.

We can collect all the data. That's not a problem anymore. We can even handle all the data. We can store all the data. The real problem is not having a strategy which allows us to filter the data so that the opportunity for success and generating actionable intelligence is high. And that calls once again for collaboration and an overarching strategy for our intelligence operations.

MR. VIOLA: I'd like to comment on what you just said there, Tim, and actually go back to what Mr. Pappas said about you can invent it, but they won't let you use it. I think that one of the things that's been brought up here is not that we don't have the ability to create the technology that we need, maybe that we even use the technology that we have.

The question is, are we using it as effectively as possible, because in essence we're drowning in data. A lot of data is out there, and having worked with the NRO, I can tell you we are collecting a lot more data. The question is what do you do with it? And I'm going to read from a report which you can read online on the Internet, and it has to do with my discipline, MASINT.

It said, "There was MASINT reporting on WMD," and this is in Iraq. "The National Intelligence Council board noted that from June 2000 through January 2003, MASINT sources produced over 1,000 reports on Iraqi WMD, none of which provided definitive indication of WMD activity."

Well, how many do you need, 1,001, 1,050, 2,000? How many reports do you need, 3,000? How many reports do you need until you hit the one you need? Well, having worked in some of those circles, I'm here to tell you that it's not just the fact that you have the winning answer. You have to have somebody who's going to be able to make that winning answer known to the person who needs it.

And one of the things that we take for granted is that we can collect a tremendous amount of information, but if you are not connected into

the right avenues to provide that data, and I'm not just talking about regular dissemination. I'm talking about person-to-person, because it still operates that way.

In many cases, that information doesn't go to the right people. It should be not just technology, and if I leave without passing on any but the following message, it should be this one. It's not about technology. It's about people. Ultimately the people have to use this information, and the people are the ones who wield it, and if you don't present it in a form that you can use it, then it will be unusable to the people who need it.

So I guess my slant on that is we have a lot of data to collect. It is a needle in a haystack, but in many cases, we may have the winning answer. We just don't present it, in many cases, to the people who need to see it when they need to see it, and that's its own challenge. It's not just dissemination. It's intelligent dissemination.

PARTICIPANT: Going back to the Wiki blogs thing, where I work I work on Intelink. I put up a website for a committee, and I have found what the people who train on Wikis and blogs and Intelink, they've transformed a whole bunch of stuff from Wikipedia over to the classified side, and I have found that I have been able to integrate everything that I collect for my position for the committee and put it up on Intelink on Intellipedia.

The beauty of Intellipedia is if you put a certain type of bracket around a certain link, this term will show up everywhere and automatically connect to the same terminology elsewhere. It's hard for me to describe. Probably my description is very limited, but the fact is it is a great collaboration community, and it depends upon the people who put into it.

I highly recommend it. I also do a blog, and I place my links in the blog, because I do seminars for where I work, and I want to be able to connect what we're putting up posting there to whoever else is putting up there, and it is marvelous collaboration. I have to tell you, I get little comments back on my blogs and on my discussion pages in back of the Wikipedia that you put up.

I get kudos all the time for that. People say, "I didn't know that you guys did that," and I see this every day of people who put up on Intellipedia who are talking to people clear across the country or around the world on these very subjects, missiles and whatever they're working on, Iraq, whatever it is. People are coming together that never would have gathered this information.

And we don't have to have this conversation a dozen times. We can go back, because it's already there. It's up there forever, and the next person that comes along can, even after So-and-So retires, the next person that comes along can pick up all that information and start where the other person left off, and that's the beauty of the collaboration. So I just wanted to put a plug in for that.

MR. VIOLA: I've actually seen this. It creates its own paper trail. It's fantastic. You have this evidence trail behind you. I will submit one thing, though, and that is you have this great collaboration tool, but you've got to get the person on, and they don't want to log on, and they don't know what their password is, and they only read things on paper.

Am I the only one who's ever seen this before? They will only read it on paper. I mean, I have my own theories as to why, but it's true, and change is hard. It's a cultural issue where you literally have to change your own internal culture for it to happen.

We may have the technological solutions, but the question is, are people going to look at it, and that is a real challenge. That takes a special skill that the rank technologist might not have, that kind of educator, coddling, nurturer type person to get them to change, and it's very, very hard.

PARTICIPANT: They're teaching us that this is a bargaining process. It's a growing thing.

MR. VIOLA: It does take a lot of time, change, yes, and sometimes we can't wait, as we've seen with some of the operational situations. We can't wait, and we have to push the issue, but it is definitely a gardening issue. I would agree with that.

MR. CLEARY: You're right. There is technology development and fielding that has to be rapid, but in terms of this gardening thing, and I think that's a great term that you used, because when you talk about—we're all in here talking about developing and using technology to solve our problems, primarily for intelligence.

It's like a bonsai tree. You have to groom that thing every so often, and you have to groom it not from the sense of hard technologies. It's what you're talking about in terms of changing the way people are thinking about things, bringing the right people together to work the issues.

I don't want a bunch of operators in a room working technology issues. I want an engineer in there. I want an analyst in there. I may want a weather person, and I don't just mean for the rain. I mean for the environment, because that person must know all the environmentals.

I want to bring everybody that I can in, so I can make sure that the technology solution that I do come up with at the end of the day is something that's going to be spot on to what I need it for. And those kind of tools that you're talking about do that - it is a bonsai tree - it grows slowly, and you've got to trim it.

PARTICIPANT: I want to comment on the technology forecasting question. I guess my thought was to tail off of what Mr. Pappas had said about it's not enough trying to find that needle in the haystack. You need to focus your

efforts on the right haystack. And then we learned about technology surprise. Part of our jobs as intel analysts is preventing technological surprise.

Well, it's difficult to do that if you don't know what technologies are coming down the pike, and I understand your point about days. That's very important. The years are important, also, and from that perspective, we only have so many dollars to dedicate toward 6.1, 6.2, 6.3 efforts.

If we could refine the haystacks or define which haystacks we would like to search for those needles, maybe using a technology forecast effort that's directed by the community, I think we could get there faster, more efficiently, with more dedicated effort.

LT. COL. MURPHY: Have you ever heard of the Proteus Project? Proteus is something that was done at the NRO a few years back, and they got all sorts of people together to sit around and think about what are the most likely worlds to exist in 2020, and then they looked at each of these worlds. They gave them names and thought, "Well, which technologies should we be developing which will address most of the problems or most of the challenges that come out of these possible worlds that lie ahead?"

Now there could be a real answer that wasn't among the scenarios, as they are called, but it was an interesting approach to try and prioritize your long distance funding based on covering as many of the problems in the future as seemed likely. And that's one way to take the 6.1 money and kind of focus it a little bit and then as I said, with like a five or ten percent chunk, and then the rest of it may be more toward applied technology.

PARTICIPANT: I agree wholeheartedly. I think the issue is that I'm disappointed that we just found out that there is a cryptologic community technology forecast that's been in existence for eight, nine years that's gone away. Who made that decision? Why would you do that? We live and breathe with this, but somebody made that call, and how do you do that over? How do you recapture that? That's a lost asset.

PARTICIPANT: I'd like to comment on how to become aware of what the problems are in the community and the research that's going on in the community. There are a lot of forums for doing this if you know where to go. For example, the Naval Post-graduate School has a weeklong program every year called the Classified Advanced Technology Update.

And you have all the services coming out there pitching their technologies, their new systems, and the problems that haven't been solved yet. The Intelligence Community, NSA, CIA participate in that and so on. And granted, you have to have clearances to get in, but you get exposed to the technology.

There are other organizations like the Directed Energy Professional Society who have several conferences a year. You get kind of the straight scoop from a technology standpoint at a lot of these things you can find just by going

on the Internet and looking up when these conferences are going to take place. So it takes a little bit of energy on your part.

Somebody just mentioned a cryptologic update. Well, I'll tell you, NSA gives an annual cryptologic update, so they give this at the Classified Advanced Technology Update, all right, at the Naval Postgraduate School. So there are areas where you can pursue some of these things.

PARTICIPANT: If I could just follow on real quickly with a comment that the Colonel made reference the Proteus project. The National Intelligence University has sponsored the Proteus Management Group as a follow-on to the work that was done under the Proteus Project by the NRO. You can find it on the Internet.

Canada has also set up Proteus Canada. The one for here in the United States is at www.carlisle.us.army/proteus, and it also links over to Proteus Canada. You can register and sign on as a member there.

If you're on Intelink and would like to learn more about the recent conference, go to Intellipedia and type in "Proteus Management Group." This is just getting started in about the last year, but again, it's to look at the Proteus insights, to look at futures, and in a whole wealth of things. So the sky is the limit, whether it's science, technology, social, cultural, economic, et cetera, again, to look at this whole aspect.

And we had a very interesting workshop at the end of August, and although I haven't seen the briefings online on the unclassified side, you could certainly contact Bill Wimbish, and his contact information is there on the homepage, and I'm sure he'd be more than happy to send you any information about it or perhaps send you a CD, too, if you were interested.

MR. REYNOLDS: I might add an additional comment about this whole notion of forecasting and what is available. The beauty of the National Intelligence Council reports, Global Trends, really is the fact that it was a dialogue, an unclassified dialogue among experts, and the NIC had the wisdom to reach out to the academic community and others for advice that they could not provide from within.

Now that's a very significant admission, but it's also a very enlightened approach, and I would submit that the general tenet of my remarks is that in an open source environment, we have a wealth of information in science and technology and engineering, and we're not mining it well. And it's probably as much a function of the fact that we don't read Mandarin.

Many people do not really exist in the technology and engineering fields that read Mandarin or Russian, for that matter, or Hindi or Arabic. Think of the frustration we had in looking at the evidence we brought in when we took down Al Qaeda and other asymmetric threats and couldn't really read what we were acquiring quickly enough to respond to it.

So this goes in the general context of social and behavioral sciences, language skills, all fusing together with our science and technology disciplines, the multidisciplined and multicultural approach to things. And I would submit that if we can focus on open source, get better desktop tools, analytical tools to separate signal from noise to a greater extend than we have been, it will be a step in the right direction.

As a final point for our culture, let me say that we haven't been idle in this effort to bring more S&T literacy to the State Department. Two weeks ago Monday, ten days ago, we started 28 American Association for the Advancement of Science Fellows on their billets in the State Department all over the place, in functional and regional bureaus. We have as many as a half a dozen professional society fellows still active in the State Department, including my good friend Shara Williams up there, our American Chemical Society Fellow, Ph.D. chemist.

And we have a new cadre of Jefferson Science Fellows. This is one of George Atkinson's initiatives to bring tenured professors, scientists, and engineers to the State Department for one-year assignments, embedded in the State Department and subsequently five years on a consultancy basis when they return to their chairs.

Now I can't think of a better way to multiply and to leverage human assets, and I go back to Mark and Michael's comments that this is an issue of personnel management. This is a people issue. This is all about people, and, as Mark said, intelligent dissemination of our work and our requirements.

I would say as the next step, the challenge to the State Department, the diplomat of 2010 that we are seeking to cultivate and grow inside is a chemist or physicist or an electrical engineer, maybe gone to master's level, who says, "I'm not really interested in working for industry. I'm not going to be an educator, and I'm not going to work on the research bench. I want to work in international relations." Bring it on. We would love to have those assets in the foreign service or in the civil service.

And the next step in this evolution is as our numbers increase, as we leverage our excellent professional fellows and build more people into our foreign service and civil service ranks, we need to put more scientists and engineers in our embassies overseas to be the first line of collection, if you will, in the open source environment, and as an integrated member of an embassy team, to therefore be an excellent vehicle for listening and for warning, in a sense, because a host country is going to be working in particular disciplines.

And heaven knows that we have talented Foreign Service officers who are economists and political scientists and great linguists, but they don't know a screw from a satellite when it comes right down to it, and if you have a scientist or an engineer embedded in your embassy, there's a union card.

As Norm Neureiter, our first advisor, used to say, it's a union card. You knock on the door of a counterpart's laboratory, you may have even worked with this person in your graduate work, you can say hello and go in and kick the tires, and by God, this is where to be—look at the foreign embassies in this country. Look how they staff their science and technology sections. They're filled with scientists and engineers. You know, Vanover Bush said in *The Endless Frontier* that it would be in our enlightened self interest as a nation to have a scientist and an engineer in every major embassy. In the late forties he said that, and he even said maybe a health scientist would be the best choice under the circumstances.

So it is where we must go again. We had a decent critical mass that was substantively supported by NASA and by the Atomic Energy Commission, becoming the DOE in the old days. Health and Human Services to some extent have specialists still abroad, but we have seen that cadre of specialists wane to such an extent that we don't have real good insights overseas in our embassies as to where the host country science and engineering enterprise is really going.

LT. COL. MURPHY: I think that's an excellent suggestion. I think that's a wonderful point. I also think that there's a real challenge with having technical people in each of the embassies, and it seems to me that we should have the capability to do so.

I know that you sometimes have to press the flesh and kick the tires, but the intelligence operations center of the future is going to be a remote operations center. It's not going to be sitting next to the person that needs the information, and it seems to me we perhaps should pursue having, a matrix, a cadre of technical experts that regularly interact with specific leads or consult with specific embassies overseas, rather than try a put a body in every embassy.

I mean, we're having enough trouble getting science and technologists to fill all the billets that we have now. But, with this capability for virtual presence, we should look at that, as well.

AUDIENCE: I work at the State Department, I feel my job is very important, and I do get awards. I just got one yesterday. I run a database for export controls, and we deal with many countries in the world. I think last count was 39 countries, and it's not only data sharing.

I have to get on the phone with my computer people and commerce people. I can pull up everything on my screen from all the agencies to see who's doing what. If my two lawyers need something, they get it. I read the first line of the comments section, expedite, underline it. It goes right out of the pile from the tickler.

It's implementing a system. The data sharing is fine, but you have to do your system. I implemented my own system from creating the tickler, pulling

out cases that go back for 30 days or 20 days, whatever. I set up a shell. I did the whole system myself. It works for the people that I have to answer to.

It's not only that. It's things that need to go out for clearances, to the desks, before you can send it to Iraq, to anywhere in the world. So it's a big job, and it's not only computers. It's walking. It's manpower, and I will say the State Department has an efficient system.

MR. VIOLA: She is not a plant, okay. My next question actually has to do with this a little bit, and I want to thank you for bringing up that point, because it is obvious that we're having problems. In fact, this question is a question about the problems, but I think there are a lot of solutions, and we've already seen how the solutions worked in the past, and I'd like to bring up some of those possible solutions from the past.

The question says, "We have had repeated massive problems with integrating big problems like Army Feature Combat System and Naval Systems. Are we outrunning our ability to integrate large technology programs, and part two, if we are, how will that impact our ability to exploit revolutionary technology?"

Okay, well that's where I just came from, and I'm here to tell you that integration is not easy. It is really hard, and here's why. It has to do, again, with the people who allocate those resources.

Here's one of the interesting things about integration. In an intelligence agency, a loose confederation that was dominated by agencies, and that's how it was formed, a loose confederation dominated by agencies, the winners were the agencies that could build themselves strong enough. And they built stovepipes, and stovepipes persisted, because stovepipes work. They really do.

You protect people. You allocate resources. You home grow your solutions for what you need. But when you have to integrate, and you have to go from one stovepipe to the next, it's not easy, and it requires a tremendous, tremendous amount of legwork.

And one of the jobs that I just came from was integration and integrating across agencies. And I'm here to tell you it is not an easy thing. Those walls are efficient internally, but they function against you externally, and it is not an easy task to go from an NGA to an NRO to organizations that you would assume would have a transparent dialogue. I mean, even if they're all populated by Air Force officers, it doesn't matter. The dialogue is going to be constrained by those stovepipes and the history behind them.

One of the things that I realized about stovepipes that's very problematic is that it comes down to people who are willing to do that kind of work. On the last program I was working, someone kept turning to me in the meeting and saying, "There are five people in every program that make it work, just five. Any more than that, and forget it. It's going to get bogged down. It's going to get completely dragged down into the mud."

And after a while it became obvious that it was very, very personality-dependent, and if you have five or a few very good people with initiative, you could get across those barriers. But those barriers keep getting in the way, and so it became a cultural issue. We had the technological solution. In fact, the technological solution had been developed over a decade prior. It was the question of whether or not to integrate it between two agencies.

So it is a very, very tough problem, and the solution comes down to the people who are executing it. Can they get over their own individual organizations' biases and allow loss for the greater gain? Can they contribute to the team, as Mike mentioned, and accept the fact that they're not going to get everything that they want initially for the greater good? And that's a very tough proposition. It always is, and that's one of the problems with integration.

So the question asked, is integration going to get tougher? Well, I'm here to tell you that integrating today's technologies is tough enough. Revolutionary technologies are an even bigger challenge, and I'm not really sure what the answer is to that, but we can go to history.

I have with me a letter, and I'm not sure why I carry this around. This is the letter that Albert Einstein wrote to Franklin Delano Roosevelt. This is it. You can get this letter on the Internet. Just write in "Einstein letter," and it pops up in Google. It's less than two pages, and he basically lays out the Manhattan Project in less than two pages. He didn't need the other four people. He did it all on his own.

And essentially what it comes down to is some of the examples in the past worked really, really well, e.g. the Manhattan Project. I think one of the reasons why the Manhattan Project worked wasn't just because it was an Oppenheimer, but because it was a General Groves. We had somebody marshaling all of the intellect, and then you had somebody on the other side who was, for the lack of a better term, kicking butt and taking names, and he was making sure that the program survived.

So we went back to your question about resources. Maybe it can't all be done with one person. Maybe you do need two people. I mean, Einstein could do it, but he was Einstein. How many Einsteins are out there? Maybe you do need two people. Maybe you do need, as you were mentioning, a technology person, along with the person who gets you access, and that's going to require a little bit of teaming.

BIOGRAPHIES

A. DENIS CLIFT

President, National Defense Intelligence College

A. DENIS CLIFT WAS APPOINTED PRESIDENT of the National Defense Intelligence College in 1994. The College, in the Department of Defense, is the nation's only accredited academic institution awarding the Master of Science of Strategic Intelligence degree and the Bachelor of Science in Intelligence degree. In 1999, in his role as President of the College, Mr. Clift was elected to serve as a Commissioner on the Commission on Higher Education of the Middle States Association of Colleges and Schools for the term 2000-2002. In 2002, he was re-elected for the term 2003-2005. Since 1992, he has also served as a U.S. Commissioner on the U.S.-Russia Joint Commission on Prisoners of War/Missing in Action, a commission created by Presidents George H. W. Bush and Boris Yeltsin with the humanitarian goal of accounting for servicemen still missing from past conflicts.

Mr. Clift was born in New York City, New York. He was educated at Friends Seminary, Phillips Exeter Academy (1954), Stanford University (B.A. 1958), and The London School of Economics and Political Science, University of London (M.Sc. 1967). He began a career of public service as a naval officer in the Eisenhower and Kennedy administrations and has served in military and civilian capacities in ten administrations, including 13 successive years in the Executive Office of the President and The White House. From 1971-1976, he served on the National Security Council staff. From 1974-1976, he was head of President Ford's National Security Council staff for the Soviet Union and Eastern and Western Europe. From 1977-1981 he was Assistant for National Security Affairs to the Vice President of the United States. From 1991-1994, he was Chief of Staff, Defense Intelligence Agency, following service as an Assistant Deputy Director and Deputy Director for External Relations of the Agency. He is a veteran of two Antarctic expeditions, including the 1961 Bellingshausen Sea Expedition. From 1963-1966, he was Editor, United States Naval Institute *Proceedings*.

His awards and decorations include the President's Rank of Distinguished Executive, awarded by President George W. Bush in 2001, the President's Rank of Meritorious Executive, awarded by President Ronald Reagan

in 1986, the Department of Defense Medal for Distinguished Public Service, the Department of Defense Distinguished Civilian Service Medal, the Secretary of Defense Meritorious Civilian Service Medal, the Secretary of the Navy Commendation for Achievement, the Oceanographer of the Navy's Superior Achievement Award, and the Director of Central Intelligence's Sherman Kent Award and Helene L. Boatner Award. He directed the production of the film "Portrait of Antarctica" screened at the Venice Film Festival. His published fiction and nonfiction include the novel *A Death in Geneva* (Ballantine Books of Random House), *Our World in Antarctica* (Rand McNally), *With Presidents to the Summit* (George Mason University Press), *Clift Notes: Intelligence and the Nation's Security* (NDIC Writing Center Press), and *Intelligence and Accountability*, (co-author), scheduled for publication, Praeger, 2007.

ANTHONY G. OETTINGER

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ANTHONY G. OETTINGER IS THE GORDON MCKAY PROFESSOR of Applied Mathematics and Professor of Information Resources Policy at Harvard University. He chairs the Board of Visitors of the National Defense Intelligence College and heads the Director of National Intelligence's Intelligence Science Board. He is a member of the Council on Foreign Relations and of the International Advisory Council of the Toda Institute for Global Peace and Policy Research. He is also a Trustee of the Charles Babbage Foundation.

Dr. Oettinger founded the Harvard Program on Information Resources Policy in 1972 to create useful knowledge, both competent and impartial, on controversial information matters.

From 1997 to 1998, he served on the Banking and Finance Sector Study Team that contributed to the report, *Preliminary Research and Development Roadmap for Protecting and Assuring Critical National Infrastructures*, issued by the President's Commission on Critical Infrastructure Protection and the Critical Infrastructure Assurance Office in July 1998. From 1996 to 1998 he was a member of the National Library of Medicine's Long Range Planning Panel on International Programs.

In the White House, Professor Oettinger was a consultant to the President's Foreign Intelligence Advisory Board (1981-90), the National Security Council (1975-81), and the Office of Science and Technology (1961-73). He chaired the Massachusetts Cable Television Commission (1975-79) under Democratic governor Michael Dukakis, having been on it from its start in 1972 under Republican governor Francis Sargent. He founded the Computer Science and Engineering Board of the National Academy of Sciences and chaired it from 1967 to 1973. He was also on the Research Advisory Board of The Committee for Economic Development (1975-79) and a consultant to Arthur D. Little, Inc. (1956-80), as well as on the Scientific Advisory Group of the Defense Communications Agency (1979-90, now DISA, the Defense Information Systems Agency), on the Command, Control, Communications, and Intelligence Panel of the Naval Research Advisory Committee (1978-82), and a member of the Information Warfare panel of the Naval Studies Board of the National Academy

of Sciences (1993-1995). From 1963 to 1967 he was an advisor to NASA's Apollo moon-landing program

From 1966 to 1968 he was president of the Association for Computing Machinery. He is a Fellow of the American Academy of Arts and Sciences, the American Association for the Advancement of Science, the Association for Computing Machinery, and the Institute of Electrical and Electronic Engineers, the last "for pioneering contributions to machine language translation, to information retrieval, and to the use of computers in education," contributions detailed in *Early Years in Machine Translation: Memoirs and Biographies of Pioneers*, edited by W. John Hutchins (John Benjamins Pub. Co., 2000) and in *Makin' Numbers: Howard Aiken and the Computer*, edited by I. Bernard Cohen and Gregory W. Welch (MIT Press, 1999).

RITA R. COLWELL

Distinguished Professor, University of Maryland College Park and Johns Hopkins University Bloomberg School of Public Health
Chairman, Canon U. S. Life Sciences, Inc.

DR. RITA COLWELL IS DISTINGUISHED UNIVERSITY PROFESSOR both at the University of Maryland at College Park and at the Johns Hopkins University Bloomberg School of Public Health, and Chairman of Canon U.S. Life Sciences, Inc. Her interests are focused on global infectious diseases, water, and health. She is currently developing an international network to address emerging infectious diseases and water issues.

Dr. Colwell served as the 11th Director of the National Science Foundation, 1998-2004. In her capacity as NSF Director, she served as Co-chair of the Committee on Science of the National Science and Technology Council. Her major interests include K-12 science and mathematics education; graduate science and engineering education; and the increased participation of women and minorities in science and engineering.

Dr. Colwell has held many advisory positions in the U.S. Government, nonprofit science policy organizations and private foundations, as well as in the international scientific research community. She is a nationally-respected scientist and educator, and has authored or co-authored 16 books and more than 700 scientific publications. She produced the award-winning film, *Invisible Seas* and has served on editorial boards of numerous scientific journals.

Before going to NSF, Dr. Colwell was President of the University of Maryland Biotechnology Institute and Professor of Microbiology and Biotechnology at the University of Maryland. She was also a member of the National Science Board from 1984 to 1990.

Dr. Colwell has previously served as Chairman of the Board of Governors of the American Academy of Microbiology. She has also served as President of the American Association for the Advancement of Science; the Washington Academy of Sciences; the American Society for Microbiology; the Sigma Xi National Science Honorary Society; and the International Union of Microbiological Societies. Dr. Colwell is a member of the National Academy of Sciences; the Royal Swedish Academy of Sciences; the Royal Society of Canada; the American Academy of Arts and Sciences; and the American Philosophical Society.

Dr. Colwell has been awarded 47 honorary degrees from institutions of higher education, including her Alma Mater, Purdue University. She is also the recipient of the Order of the Rising Sun, Gold and Silver Star, bestowed by the Emperor of Japan. Dr. Colwell is an honorary member of the microbiological societies of the UK, Australia, France, Israel, Bangladesh, and the U.S. and has held several honorary professorships, at institutions that include the University of Queensland, Australia. Colwell Massif, a geological site in Antarctica, has been named in recognition of her work in the polar regions.

Dr. Colwell holds a B.S. in Bacteriology and an M.S. in Genetics from Purdue University, and a Ph.D. in Oceanography from the University of Washington.

ARIS A. PAPPAS

Deputy Director
Microsoft Institute for Advanced Technology in Governments

ARIS PAPPAS IS DEPUTY DIRECTOR of the Microsoft Institute for Advanced Technology in Governments. The institute was founded in September 2004 to identify large-scale and difficult problems in the government environment and link them to Microsoft's vast research and development potential.

Prior to joining Microsoft, Mr. Pappas was co-founder and vice-president of Intelligence Enterprises, LLC, a consulting firm supporting a broad range of customers ranging from the space-based imagery industry to the Department of Homeland Security. He is also a member of a select study group commissioned to review the performance of the Intelligence Community with respect to Iraq.

His principal professional experience is 34 years of Federal service, six with the Army and 28 with the Central Intelligence Agency, retiring as a member of the Senior Intelligence Service. At the CIA, he held a number of positions in both the Intelligence (analytic) and Operations Directorates. He was an Assistant National Intelligence Officer during the first Gulf War, and later Executive Secretary of the Director of Central Intelligence's (DCI) Intelligence Science Board. After a year-long tour at the FBI, Mr. Pappas established the DCI's Homeland Security Staff.

Mr. Pappas holds a Bachelor's Degree from The City College of New York and a Master's Degree from Boston University, both in International Relations, and is a graduate of the U.S. Navy War College. He is an avid movie buff and holds a Commercial Pilot's license with an instrument rating. His other hobbies involve scale modeling: HO trains and aircraft. Mr. Pappas is the Chief Judge of the International Plastic Modelers Society, has models on display in the National Air & Space Museum, and contributes to various hobby journals.

GEROLD (GERRY) YONAS

Vice President, Advanced Concepts, and Principal Scientist
Sandia National Laboratories

DR. GEROLD (GERRY) YONAS IS VICE PRESIDENT AND PRINCIPAL SCIENTIST at Sandia National Laboratories, a subsidiary of Lockheed Martin Corp.

His career began in 1962 as senior scientist at the jet Propulsion Laboratory, where he was responsible for original research in magneto fluid dynamics and solar physics. In 1967 he joined Physics International and was responsible for investigating the physics of high-power electron beams.

In 1972 he joined Sandia, where he initiated and directed the particle-beam fusion program, particle-beam weapon program, advanced-simulation development, and applications activities, as well as development of Sandia's Pulsed Power research capability which remains one of the world's premier pulsed-power research and applications centers.

In 1983 he was selected to Chair the Directed Energy Weapon Panel of the "Fletcher" study forming the basis for the Strategic Defense Initiative Program. Later, he became the first Chief Scientist for the Strategic Defense Initiative Organization (SDIO) and its Acting Deputy Director. From 1984-1986, he provided technical management, oversight, and strategic planning for the SDIO during its formative years. In 1986 he joined Titan Corporation as President of Titan Technologies.

Dr. Yonas returned to Sandia in 1989 as Director of Laboratory Development. In 1991 he became Vice President of Systems Applications and focused on strategic leadership in new initiatives in global surveillance, battlefield sensors, and nonnuclear high-precision weapons. In 1995 he became Vice President of Systems, Science, and Technology. In 1999 he initiated Sandia's Advanced Concepts Group.

He has published extensively in the fields of intense particle beams, inertial confinement fusion, strategic defense technologies, and technology transfer. He received the BEAMS prize Award; the Peter Haas Award by the Institute of Electrical & Electronics Engineers; the Fusion Power Associates Leadership Award; and the Secretary of Defense Medal for Outstanding Public Service for "exceptionally meritorious service to his country by significant contributions to the nation's Strategic Defense Initiative." He also holds a U.S. Patent for a Relativisitic Electron Beam Accelerator concept.

He is a Fellow of the American Physical Society and a Fellow of the American Institute of Aeronautics and Astronautics. While a member of both Sigma Xi and Tau Beta Pi, he also serves on the U.S. Special Operations Command Science Panel; the U.S. Army Science Assessment Group; the U.S. Senate Select Committee on Intelligence's Technical Advisory Group; and the Center for Strategic & International Studies Commission on Global Aging. In addition, he serves on the Advisory Council of the School of Electrical and Computer Engineering at Cornell University, and the Electrical and Computer Engineering Advisory Council at the University of New Mexico.

Dr. Yonas received a B.S. in Engineering Physics from Cornell University; a Guggenheim fellowship for graduate study at California Institute of Technology; and a Ph.D. in Engineering Science and Physics.

ANDREW W. REYNOLDS
Deputy and Chief of Staff
Office of the Science and Technology Advisor to the Secretary of State

MR. REYNOLDS, A CAREER CIVIL SERVANT, is Deputy and chief of staff in the Office of the Science and Technology Advisor to the Secretary of State (STAS). He opened the office in September 2000 with the first Advisor, Dr. Norman Neureiter, and now serves his successor, Dr. George Atkinson, who began his three-year appointment in September 2003. The STAS leads efforts to augment S&T personnel and literacy at the Department, to strengthen outreach to the domestic and international S&T community, and to foster mid- to long-term strategic planning for S&T issues as they relate to foreign policy within the U.S. government, including the defense and intelligence communities.

Reynolds joined the State Department in 1990 as Deputy Director of the Office of Science and Technology Cooperation. In this capacity he worked extensively in Western and Eastern Europe, Russia, the former republics of the Soviet Union, India, Indonesia, and Japan to facilitate bilateral and multilateral cooperation in S&T fields. Reynolds led the first USG government S&T delegations in 1992-93 to initiate cooperation with the three Baltic States, Belarus, Ukraine, and Kazakhstan, and negotiated and concluded cooperative S&T agreements with all six nations. He received a Meritorious Honor Award for his work. From 1994-96 he led efforts to integrate cooperation on S&T and environmental issues in support of the Cooperative Commission co-chaired by Vice President Al Gore and Russian Prime Minister Viktor Chernomyrdin. From October 1996 to August 2000 he served as Counselor for Environment, Science and Technology at the U.S. Embassy in Rome under a Limited Foreign Service appointment. In that position Reynolds was responsible for bilateral and related EU relations in basic S&T research, technology policy, export controls, IPR protection, energy, space, health, oceans and fisheries, and environment and sustainable development issues. He received a Superior Honor Award for his performance and contributions.

Mr. Reynolds began his professional career in 1974 with Systems Sciences Incorporated, Washington, D.C., as a researcher for energy and public health issues. He joined the Federal Energy Agency in 1975 and, subsequently, the Department of Energy (DOE), where he led a section specializing in electricity, nuclear power and economic analysis. From 1983-1986 he was posted in Paris as DOE Representative for Europe and focused on energy, environment, and S&T cooperation through the OECD Nuclear Energy Agency, the International Energy Agency, and the OECD Environment Directorate. From 1986-1990 he was Deputy Director in the DOE Office of International S&T Cooperation. In that assignment Reynolds also served as Executive Secretary

for the U.S./Soviet Agreement on the Peaceful Uses of Atomic Energy to facilitate joint research in high-energy physics, controlled thermonuclear fusion, environmental restoration and waste management, and nuclear reactor safety. He is an expert on the Three Mile Island and Chernobyl accidents.

Mr. Reynolds combined pre-medical and international relations studies as an undergraduate University Scholar at the University of Virginia, including overseas studies at the University of Copenhagen in Denmark. He completed graduate work in energy technology management at George Washington University and is currently enrolled at the National Defense Intelligence College pursuing an M.S. in Strategic Intelligence. He speaks and reads Spanish, Italian, French, and some German.

ERIC HASELTINE

Associate Director of National Intelligence for Science and Technology
Office of the Director of National Intelligence

AS THE ASSOCIATE DIRECTOR OF NATIONAL INTELLIGENCE for Science and Technology, Dr. Haseltine is responsible for leading the Intelligence Community to a coherent S&T Strategy that insures IC dominance and use of world-class R&D processes.

Dr. Haseltine was the former Director of Research at the National Security Agency from 2002 until his new appointment with the Director of National Intelligence in June 2005. Before joining NSA, Dr. Haseltine was the Executive Vice President of Research and Development at Walt Disney Imagineering, Disney's R&D division, where he oversaw key technology initiatives and managed the Virtual Reality Studio. Dr. Haseltine also spent thirteen years with Hughes Aircraft. There he held the positions of the Director of Engineering, the Program Manager for Aircraft Simulator Programs, and the Head of the Human factors for the Radar Systems Group.

With over 100 publications in journals such as *Brain Research, Neuroscience Proceedings* and *ARVO Proceedings*, Dr. Haseltine has also been a contributing editor to *Discover Magazine* where he writes a monthly column on the brain. Dr. Haseltine holds twelve (12) patents in the field of laser projection, optics, head-mounted displays, animation tools and special effects.

Dr. Haseltine has served on several Government Advisory Boards including the Army STRICOM Technology Advisory Board and the NIST Advanced Technology Program. Dr. Haseltine holds a BA in Economics and Psychology from the University of California, Berkeley, and a Ph.D. in Physiological Psychology from Indiana University.